Ecosystem Based Fisheries Management from concept to practice: Australia, a case study

By
Helen Webb BA

Thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy,
University of Tasmania, Australia

August 2010

CONTENTS

ABSTRACT ... xi

DECLARATION OF ORIGINALITY ... xiii

STATEMENT FOR AUTHORITY TO ACCESS ... xiv

ACKNOWLEDGEMENTS ... xv

ACRONYMS ... xvi

PART ONE: ECOSYSTEM BASED FISHERIES MANAGEMENT THE CONCEPT

CHAPTER 1: INTRODUCTION ... 1
1.1 Background ... 1
1.2 Significance of the research ... 5
1.3 Research aims and objectives ... 7
1.4 Research design and approach ... 8
1.5 Thesis outline ... 11

CHAPTER 2: SUSTAINABLE DEVELOPMENT AND ECOSYSTEM BASED FISHERIES MANAGEMENT ... 14
2.1 Introduction ... 14
2.2 Sustainable development: concept and practice ... 15
2.2.2 The World Commission on Environmental Development (WECD) ... 16
Our Common Future Chapter 10: Managing the Commons ... 17
Our Common Future Chapter 12: Towards Common Action ... 19
2.2.3 United Nations Conference on the Environment and Development ... 20
The Rio Declaration on Environment and Development ... 21
Agenda 21 ... 21
Chapter 17 Protection of the oceans, all kinds of seas, including enclosed and semi-enclosed seas, and coastal areas and the protection, rational use and development of their living resources ... 21
Chapter 35: Science for sustainable development ... 22
Chapter 39: International legal instruments and mechanisms ... 23
2.2.4 World Summit on Sustainable Development ... 24
Johannesburg Plan of Implementation ... 24
2.2.5 The Commission for Sustainable Development ... 26
2.3 Ecosystem Based Management ... 27
2.3.1 Ecosystem Based Management: the concept ... 27
Ecosystem Based Management: some key issues ... 29
2.4 The development of an Ecosystem Based Fisheries Management approach ... 30
2.4.1 Law of the Sea Convention and the Convention on Biological Diversity 31
United Nations Law of the Sea Convention (UNLOSC) ... 31
United Nations Convention on Biological Diversity ... 31
2.5 Ecosystem Based Fishery Management ... 32
2.5.1 Ecosystem Based Fisheries Management: the international dimension. 33
2.5.2 Ecosystem Based Fishery Management ... 37

The concept *37*
Overarching goals, objectives and principles *39*
2.5.3 EBFM: key aspects and elements **41**
Management of people or ecosystems *42*
Societal choice, values and decision-making *43*
2.5.4 Challenges in implementing EBFM **45**
2.6 Current fisheries debates and issues **46**
2.6.1 Fisheries status, futures, and management options **46**
2.6.2 Fisheries issues **49**
Over-fishing *50*
Over-capacity *52*
Government subsidies *54*
Illegal, unreported and unregulated (IUU) fishing *56*
2.7 A systems approach **59**
2.8 Summary **63**

CHAPTER 3: THE ENVIRONMENTAL, ECONOMIC AND SOCIAL DIMENSIONS OF EBFM **65**
3.1 Introduction **65**
3.2 Environmental dimensions **68**
3.2.1 The marine environment: its unique characteristics **68**
3.2.2 The importance of marine ecosystem goods and services and biodiversity **73**
3.2.3 Marine ecosystems and biodiversity **76**
3.2.4 The marine environment: principal issues and impacts **76**
Climate change *77*
Coastal zone development and land-based impacts *79*
Impacts of fishing on marine ecosystems *81*
Direct impacts of fishing *81*
Indirect impacts of fishing *83*
3.3 Economic dimensions **84**
3.3.1 Fishery production and fishing gear and methods **87**
3.3.2 Fisheries sectors, fishing fleets and technology **89**
Commercial wild caught fisheries *89*
Recreational and charter fisheries *91*
Aquaculture *92*
3.3.3 Post harvest sector **95**
3.4 Social dimensions **97**
People, communities, social capital and knowledge *99*
Employment and livelihoods *102*
Culture and self determination *104*
Food security and product quality and safety *105*
3.5 Environmental, economic and social dynamics **106**
3.5.1 The environmental, economic and social context **107**
Sustainability *107*
Resilience *110*
3.6 A biosocioeconomic subsystems model **113**
3.7 Summary **116**

CHAPTER 4: GOVERNANCE AND INSTITUTIONAL ARRANGEMENTS UNDER EBFM ... 119
4.1 Introduction ... 119
4.2 Governance and management ... 122
4.2.1 Benchmarking for fisheries governance ... 122
4.2.2 Governance functions and structures: roles and responsibilities ... 123
4.3 Governance and management: a multi level framework ... 128
4.3.1 International ... 128
Establishment of the 200 nautical mile Exclusive Economic Zones ... 130
International response to changing oceans and fisheries issues ... 131
International environmental and trade agreements ... 132
International Trade in Endangered Species of Wild Fauna and Flora ... 134
4.3.2 Regional arrangements ... 135
Regional Fisheries Management Organisations ... 136
4.3.3 Bilateral arrangements ... 139
4.3.4 Nation states ... 140
4.4 Governance and management: multiple institutions and stakeholders ... 141
4.4.1 Participatory decision-making ... 142
Participatory decision-making ... 142
Resolution of conflicting objectives and interests ... 143
Capacity and capability building ... 144
4.4.2 Governance and management: different institutional approaches ... 145
Centralisation and decentralisation ... 146
Co-management arrangements ... 147
4.5 Integrated governance and management ... 150
4.5.1 Environmental, economic and social integration ... 150
4.5.2 Multi-level governance and management ... 151
4.5.3 Multiple institutions and stakeholders and participatory decision-making ... 153
4.5.4 Institutional interplay and fit ... 156
4.6 Decision-making: complexity, uncertainty, risks, adaptive management and evaluation ... 157
4.6.1 Adaptive management ... 160
4.6.2 Evaluation ... 163
4.7 Governance and management subsystems model ... 164
4.8 Summary ... 167

CHAPTER 5: IMPLEMENTATION OF EBFM: FISHERIES STRATEGIC AND OPERATIONAL MANAGEMENT ... 169
5.1 Introduction ... 169
5.2 EBFM implementation: some key considerations ... 171
5.2.1 Steps for EBFM implementation ... 171
An incremental approach ... 172
5.2.2 The precautionary approach and how is this to be applied? ... 173
5.2.3 Management objectives, indicators and reference points ... 177
Defining goals and clearly stating objectives ... 177
Indicators ... 179
Ecosystem reference points ... 181
Reporting ... 183

5.3 Strategic fishery management **183**
5.3.1 Fisheries management and decision-making tools **184**
Management Strategy Evaluation *184*
Risk assessment *185*
Qualitative and quantitative models *187*
Mapping tools *189*
5.3.2 Industry based initiatives **190**
Codes of conduct and codes of practice *190*
Environmental Management Systems *190*
Accreditation schemes/eco-labelling *192*
5.4 Operational management **194**
5.4.1 Fisheries management plans and regulations **195**
5.4.2 Management processes and measures **196**
5.4.3 Harvest strategies and the allocation of property rights **197**
Harvest strategies *197*
Allocations in fisheries management *198*
Individual Transferable Quotas *201*
5.4.4 Spatial and temporal management **203**
Marine Protected Areas *204*
5.4.5 Performance assessment, evaluation and reporting **206**
5.4.6 Knowledge, research and data management **209**
Knowledge and date management *209*
Research *211*
5.5 A Management and decision subsystems model **212**
5.6 Summary **215**

PART TWO: ECOSYSTEM BASED FISHERIES MANAGEMENT IN PRACTICE

CHAPTER 6: OCEANS AND FISHERIES IN AUSTRALIA: THE POLICY FRAMEWORK **219**
6.1 Introduction **219**
6.2 Australia's international, regional and bilateral participation and role **220**
6.2.1 Commitments under WSSD 2002 .... **221**
6.2.2 Positioning Australian fisheries: international, regional and bilateral arrangements **224**
6.3 Adoption and development of ESD in Australian fisheries **227**
6.4 National governance and management **229**
6.4.1 National Strategy for Ecologically Sustainable Development 1992 .... **230**
Review of NSESD *232*
6.4.2 Australia's Oceans Policy **234**
Oceans Policy reviews *235*
6.4.3 Environment Protection and Biodiversity Conservation Act 1999 .... **236**
Reviews of the first round of strategic assessments under the EPBC Act 1999 .... *237*
Australian Fisheries Management Forum: the lessons and possible future directions *238*
6.5 Australia's oceans and fisheries context: governance and management responses **240**
6.5.1 Issues identified in Australia's State of the Environment reports **241**
6.5.2 Climate change: an emerging issue **245**

6.5.3 Australia's governance and management response 246
6.6 Multi-level and multi-institutional governance and management: issues of interplay and fit 250
6.6.1 Multi-level governance and management 252
6.6.2 Oceans and fisheries multiple institutions and stakeholders 254
Roles and responsibilities of the Department of Agriculture, Fisheries and Forestry 254
Roles and responsibilities of the Department of the Environment, Water, Heritage and the Arts 255
Fisheries agencies 255
Stakeholders and consultation 256
6.7 Discussion 257
6.7.1 Regional management 257
6.7.2 Bilateral arrangements 259
6.7.3 Australia's ESD and EBFM national policy framework 261
Bioregional planning 262
Coastal zone management 263
Spatial planning and MPAs 264
Fisheries 266
The state of the environment reporting 267
6.8 Summary 267

CHAPTER 7: AUSTRALIAN COMMONWEALTH AND STATE AND TERRITORY MANAGED FISHERIES UNDER ESD AND EBFM PRINCIPLES 270
7.1 Introduction 270
7.2 Australian fisheries 271
7.2.1 Fishery resources and habitats 271
7.2.2 Fishing fleets and technology 272
7.2.3 Post harvest 273
7.3 Australian fisheries: the environmental, economic and social context 275
7.3.1 Environmental dimensions 275
7.3.2 Economic dimensions 278
7.4 Commonwealth, state and territory managed fisheries: some key considerations 280
7.4.1 Consultation and participatory decision-making 281
Consultation 282
Co-management: a delegated model 282
7.4.2 Management arrangements 284
Structural adjustments and compensation 285
Monitoring, compliance and enforcement 287
7.4.3 Management processes and measures 289
Fisheries allocation between sectors 289
Allocation of user rights and ITQs 293
Harvest strategies 294
Marine Protected Areas and fisheries 297
7.4.4 Management and fishery assessments 298
Stock assessments and TACs 298
Single-species and multi-species assessments 299

Fisheries strategic assessments *300*
Risk assessments *300*
Management Strategy Evaluation *302*
7.4.5 Industry fishery assessments **303**
Environmental Management Systems *303*
Accreditation and eco-labelling *304*
7.4.6 Data and information **305**
7.4.7 Research **307**
7.5 Reviews of Australian fisheries 1998 and 2008 .... **308**
7.5.1 The 1998 review **308**
7.5.2 Work undertaken by the ESD subgroup since the 1998 review **310**
Summary of jurisdictional uptake of ESD framework as at 2004 .... *313*
7.5.3 The 2008 review **315**
7.5.3.1 The Survey: where we were, where we are now, where we need to be *316*
7.5.3.2 Summary of recommendations *321*
7.6 Discussion **323**
Toolbox development *328*
7.7 Summary **331**

CHAPTER 8: IMPLEMENTATION OF ESD AND EBFM IN AUSTRALIAN FISHERIES: TWO CASE STUDIES **334**
8.1 Introduction **334**
8.2 Commonwealth fisheries **335**
8.2.1 Biological and economic status of Commonwealth fisheries **335**
8.2.2 AFMA Commonwealth managed fisheries under ESD and EBFM principles **337**
Minister's Statutory Direction (2005) *338*
AFMA's response to the Ministerial Direction (2006) *339*
8.3 The Southern and Eastern Scalefish and Shark Fisheries: a case study **341**
8.3.1 Background and overview **341**
SESSF sectors *343*
Fishing fleets *344*
Post harvest sector *345*
8.3.2 Environmental, economic and social context **346**
Environment *346*
Economic *350*
Social *351*
8.3.3 Management of the SESSF **352**
8.4 Recent AFMA management changes and addressing issues in the SESSF **356**
8.4.1 AFMA management changes **356**
Management Advisory Committees (MACs) *356*
Delegated co-management approach *357*
Ecological Risk Management (ERM) framework *358*
ITQs and boat SFRs *359*
8.4.2 Addressing issues in the SESSF **361**
Harvest strategies *361*
Stock rebuilding strategies *363*

Listing of orange roughy as conservation dependent *364*
Structural adjustment.. *366*
Discarding, bycatch and protected species.. *368*
Chondrichthyan Technical Working Group... *370*
8.5 Western Australian fisheries management framework under ESD and EBFM principles 370
8.5.1 Biological and economic status of Western Australian fisheries sectors 371
8.5.2 Department of Fisheries managed fisheries under ESD and EBFM principles 373
8.6 The West Coast Rock Lobster Fishery: a case study... 375
8.6.1 Overview the West Coast Bioregion 375
West Coast Rock Lobster fishery sectors *377*
WCRLF post harvest sector *379*
8.6.2 Environmental, economic and social context... 380
Environmental... *380*
Economic *383*
Social.. *383*
8.6.3 Management of the WCRLF 384
8.7 Recent management changes and addressing issues in the WCRLF................. 389
8.7.1 Department of Fisheries management changes....................................... 389
Integrated Fisheries Management (IMF) Framework and EBFM.................. *389*
Management Advisory Committees (MACs) *390*
Review of management options in the WCRLF *390*
8.7.2 Addressing issues in the WCRLF.. 393
Harvest strategies... *393*
Marine Stewardship Council accreditation *396*
Deepwater ecosystems *397*
Structural adjustment.. *398*
Discarding and bycatch and protected species.. *398*
8.8 Discussion 399
8.8.1 Strategic management framework: Australian Fisheries Management Authority and Western Australia Department of Fisheries............................... 401
8.8.2 Operational management: the two cases studies 403
8.9 Summary 405

CHAPTER 9: CONCLUSION: ECOSYSTEM BASED FISHERIES MANAGEMENT FROM CONCEPT TO PRACTICE 407
9.1 Introduction.. 407
9.2 Using an integrated systems approach to model ESD and EBFM principles..... 407
9.3 EBFM: issues, drivers and the development of the concept 409
9.4 A systems approach 410
9.5 Australia: ESD and EBFM in practice... 413
9.5.1 The biosocioeconomic context 413
9.5.2 Performance reporting, adaptive management, and information and data 416
9.6 Australian fisheries: where we were, where we are now, and recommendations for where we need to be.. 418
9.6.1 Current issues and recommendations.. 418

9.6.2 Future issues and scenario analysis.. 422
9.7 EBFM in Australia 423
9.8 From theory to practice.. 425

REFERENCES 427

APPENDIX 1: PERMISSION FORMS 521

List of Figures

Figure 2.7: An integrated systems model under EBFM principles. 61
Figure 3.1: An integrated systems model under EBFM principles. 67
Figure 3.6: A biosocioeconomic systems model: ecosystem and human subsystems. 115
Figure 4.1: An integrated systems model under EBFM principles. 121
Figure 4.4.2: Continuum of co-management approaches... 149
Figure 4.5.2: A systems model of multi-level governance and management. 153
Figure 4.5.3: A multi-level institutional and stakeholders decision-making framework............. 155
Figure 4.6.1: Adaptive decision framework. 163
Figure 4.7: Governance and management dimensions and subsystems model. 166
Figure 5.1: An integrated systems model under EBFM principles. 170
Figure 5.3.1: Framework for management strategy evaluation. 185
Figure 5.5: Management and decision-making dimensions subsystems model...................... 214
Figure 5.6: An integrated systems model under EBFM principles. 217
Figure 6.5.2: Multi-level and multi- institutional governance and management. 251
Figure 7.5.2: Summary of the National ESD Reporting Framework. 312
Figure 8.8.1: Strategic and operational management framework. 401
Figure 9.4: An integrated systems model under EBFM principles. 412

List of Tables

Table 2.3.1: Summary of key issues. 30
Table 3.2.1(a): A hierarchical framework of ecosystems dimensions, components and characteristics. 70
Table 3.2.1(b): A representation of the biogeochemical processes. 72
Table 3.3: A framework for identifying and describing fisheries economic dimensions, components, characteristics and macro and micro drivers 86
Table 3.4.1: A framework for identifying and describing fisheries social dimensions, components, characteristics and drivers. 99
Table 4.2.2a: The political role and responsbilities 125
Table 4.2.2b: The policy and planning role and responsbilities 126
Table 4.2.2c: The legal role and responsbilities 127
Table 4.2.2d: The management role and responsibilities 127
Table 5.4.2: Fisheries management measures. 197
Table 6.5.1: The overall status and issues as reported in the State of the Environment reports for 1996, 2001, 2006. 243
Table 6.5.3: The key national strategies and policy initiatives 248
Table 7.5.3.1: The use of assessment and management tools. 317
Table 7.6: Progress towards ESD and EBFM implementation 326
Table 8.3.1: The SESSF sectors. 344
Table 8.3.2(a): SESSF sectors and stock status for 2008. 347
Table 8.3.2(b): SESSF sectors bycatch and habitat issues 2008. 348
Table 8.3.3: Summary of current operational management for the SESSF. 352
Table 8.6.3: Summary of current operational management for the WCRLF. 384

ABSTRACT

There are a number of reasons for the move towards sustainable development and ecosystem based fisheries management. Public concern and awareness over the impact of development on the environment started in the 1960s and 1970s with the emergence of the environment movement and the global sustainability debate. This was in response to visible effects of degradation on the environment caused by human activities, and a challenging of traditional assumptions that the natural environment had the capacity to provide unlimited resources for continued economic and population growth. The past two decades has been characterised by an acknowledgement that previous management approaches have failed to effectively address the issues effecting oceans and fisheries, and the growing realisation that a holistic approach is required to ensure the proper governance and management of the oceans and fisheries. The overall objective of EBFM is to sustain healthy marine ecosystems and the fisheries they support.

There is now a large literature on EBFM, but much less on implementation and no general agreed framework for assessing EBFM. A systems approach is one way to deal with the above difficulties. The central proposition of this thesis has argued that managing under ESD/EBFM principles is complex and one needs to understand the big picture in order to identify and understand the parts. This approach has been used throughout each stage of the thesis by way of unpacking the whole into its constituent parts and developing an understanding of the key dependencies and relationships; and repacking by discussing the importance of integrated governance and management in terms of consistency when translating from general concepts and definitions into principles, criteria, objectives, and the specific approaches for implementation.

To assess management strategies in the context of the overall “fisheries system” that links the marine ecosystem, users, scientists, government agencies and other stakeholders, it is helpful to begin to get a sense of what such a system might look like. To achieve this, an integrated model has been developed, which displays the broad dimensions and interconnected and interlinked nature of ecosystems and human systems under EBFM principles. The model was further developed in terms of the biosocioecomic and the governance and management dimensions, which are underpinned by a set of frameworks. These provide a framework for describing and

understanding of the dimensions, components, characteristics and key drivers for each of the dimensions.

Australia has adopted ESD and EBFM which forms the basis for governance and management of oceans and fisheries across all jurisdictions. In moving from the more theoretical and conceptual aspects to an application of ESD/EBFM, the model was applied to Australia, providing empirical material through which to qualitatively assess its application. It was argued that the conceptual model could be used to successfully represent the real world in moving from a broad representation of ESD and EBFM to the detailed implementation at the fisheries level in Australia. One area of the model that requires further development, and is necessary for fully implementing EBFM, concerns societal choice and values. Future key challenges at the international level and nationally for Australia is the need to simultaneously govern and manage both current and emerging issues, which will require different approaches; and the need to move to a fully integrated assessment approach so that adaptive management can be implemented.

DECLARATION OF ORIGINALITY

This thesis contains no material which has been accepted for a degree or diploma by the University or any other institution, except by way of background information and duly acknowledged in the thesis, and to the best of my knowledge and belief no material previously published or written by another person except where due acknowledgement is made in the text of the thesis. Some material published and researched by me has been included and duly acknowledged in the content of this thesis. These references include:

Webb, H.; and Smith, T. (2008) *Review of the scope, assessment methods and management responses for fisheries ESD and EBFM in Australia* FRDC Report 2004/101. Fisheries Research and Development Corporation and Commonwealth Scientific and Industrial Research Organisation, Hobart, Tasmania (invited Research Project, Fisheries Research and Development Corporation).

Webb, H. (2006) *Ecosystem Based Fisheries Management: a systems approach* at the ICES Symposium on Fisheries Management Strategies, 27-30 June 2006, Galway, Ireland (presentation of some preliminary research findings)

Where co-authors have been involved, express permission to use the content of this report was sought and a statement of authority and authorship has been included in Appendix 1, signed by all co-authors.

Helen Webb

Date: 23rd August 2010

STATEMENT FOR AUTHORITY TO ACCESS

This thesis is not to be made available for loan or copying for two years following the date this statement was signed. Following that time the thesis may be made available for loan and limited copying in accordance with the Copyright Act 1968.

Helen Webb

23rd August 2010

ACKNOWLEDGEMENTS

I would like to thank each of these people here for their contribution to making the completion of this thesis possible.

First, I would like to acknowledge and thank my two University of Tasmania supervisors Marcus Haward and Lorne Kriwoken; and my CSIRO co-supervisor David Smith for their ongoing support. Their contribution to this thesis has resulted in a more cogent work and provided me with a broader and more detailed understanding of the subject matter.

Second, I would like to acknowledge and thank Tony Smith at CSIRO; and CSIRO in supporting my undertaking of this thesis and presentation of the preliminary research findings *Ecosystem Based Fisheries Management: a systems approach* at the ICES Symposium on Fisheries Management Strategies, 27-30 June 2006, Galway, Ireland. I particularly value the supportive and collegiate environment within CSIRO.

Third, I would like to acknowledge and thank Patrick Hone at the Fisheries and Research and Development Corporation (FRDC); and the members of the Ecologically Sustainable Development Working Group, particularly Peter Millington, Rick Fletcher, Jean Chesson and Tor Hundloe for their support, instructive direction and informative feedback in completing the FRDC research project *Review of the scope, assessment methods and management responses for fisheries ESD and EBFM in Australia* (Webb and Smith 2008).

Finally, I wish to dedicate this thesis to John Perrett who has been an especial and valued presence in my life, and since his untimely death, remains a continual inspiration and companion on the journey.

ACRONYMS

ABARE	Australian Bureau of Agriculture and Resource Economics
ABS	Australian Bureau of Statistics
ACF	Australian Conservation Foundation
AFMA	Australian Fisheries Management Authority
AFMF	Australian Fisheries Management Forum
AFZ	Australian Fishing Zone
AHC	Australian Heritage Commission
AIMS	Australian Institute of Marine Science
AMSA	Australian Maritime Safety Authority
ANCA	Australian Nature Conservation Agency
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZLIC	Australian and New Zealand Land Information Council
APPEA	Australian Petroleum, Production and Exploration Association
AQIA	Australian Quarantine Inspection Service
ARMCANZ	Agricultural Resources Management council of Australia and New Zealand
ASIC	Australian Seafood Industry Council
ASDD	Australian Spatial Data Directory
BRD	Bycatch Reduction Device
BRS	Bureau of Rural Sciences
BSCZF	Bass Strait Central Zone Scallop Fishery
BWG	Biodiversity Working Group
CAAB	Codes for Australian Aquatic Biota
CAES	Catch and Effort Statistics
CBD	Convention on Biological Diversity
CCAMLR	Conservation of Antarctic Marine Living Resources
CCSBT	Commission for the Conservation of Southern Bluefin Tuna
CITIES	Convention on International Trade in Endangered Species
CMAR	CSIRO Marine and Atmospheric Research
CMR	Commonwealth Marine Reserves
COAG	Council of Australian Governments
COFI	Committee on Fisheries
CPUE	Catch Per Unit Effort
CSD	Commission on Sustainable Development
CSIRO	Commonwealth Science and Industrial Research Organisation
CTD	Conductivity-temperature-depth
CTWG	Chondrichthyan Technical Working Group

DAFF	Department of Agriculture, Fisheries and Forestry
DEP	Department of Environmental Protection
DEWHA	Department of the Environment, Water and the Arts
DIC	Dissolved Inorganic Carbon
DOM	Dissolved Organic Matter
DPIE	Department of Primary Industries and Energy
DWFN	Distant Water Fishing Nations
EA	Environment Australia
EAF	Ecosystem Approach to Fisheries
EBFM	Ecosystem Based Fisheries Management
EBM	Ecosystem Based Management
EcoSRG	Ecological Effects of Fishing Scientific Reference Group
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EMA	Ecosystem Management Approach
EMAS	European Eco-Management and Audit Scheme
EMS	Environmental Management System
EPA	Environmental Protection Agency
EPAP	Ecosystem Principles Advisory Panel
EPBC	Environment Protection and Biodiversity Conservation
ENSO	El Nino Southern Oscillation
ERA	Ecological Risk Assessment
ERACF	Ecological Risk Assessment for Commonwealth Fisheries
ERM	ecological risk management
EsA or EA	Ecosystem Approach
ESD	Ecologically Sustainable Development
ESDRA	Ecologically Sustainable Development Reporting and Assessment
ETBF	Eastern Tuna and Billfish Fishery
EU	European Union
FAC	Fisheries Advisory Committee
FAO	Food and Agriculture Organization
FEP	Fisheries Ecosystem Plan
FMC	Fisheries Management Committees
FMP	Fishery Management Plan
FOC	Flag of Convenience
FRAB	Fisheries Research Advisory Board
FRDC	Fisheries Research and Development Corporation
FRMA	Fish Resources Management Act
FRRF	Fisheries Resources Research Fund

FSA	Fish Stocks Agreement
GAB	Great Australian Bight
GABMAC	Great Australian Bight Management Advisory Committee
GABRAG	Great Australian Bight Resource Assessment Group
GABT	Great Australian Bight Trawl Fishery
GATT	General Agreement on Tariffs and Trade
GESAMP	Joint Group of Experts on Scientific Aspects of Environmental Protection
GIS	Geographic Information System
GNP	Gross National Product
GPS	Global Positioning System
GRMPA	Great Barrier Reef Marine Park Authority
GVP	Gross Value of Production
HACCP	Hazard Analysis and Critical Control Point
HSP	Commonwealth Harvest Strategy Policy
ICAG	Intergovernmental Coastal Advisory Group
ICAM	Integrated Marine and Coastal Management
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICESD	Intergovernmental Committee on Ecologically Sustainable Development
ICMS	Input Control Management System
ICSTD	International Centre for Trade and Sustainable Development
ICZM	Integrated Coastal Zone Management
IGAE	Intergovernmental Agreement on the Environment
IMF	Integrated Fisheries Management
IMO	International Maritime Organisation
IOC	International Oceanographic Commission
IOD	Indian Ocean Dipole
IOTC	Indian Ocean Tuna Commission
IPCC	Intergovernmental Panel on Climate Change
IPOA	International Plans of Action
ISO	International Organisation for Standardisation
ITQ	Individual Transferable Quota
IUCN	International Union for Conservation of Nature and Natural Resources
IUU	Illegal Unregulated and Unreported fishing
JOPI	Johannesburg Plan of Implementation
LME	Large Marine Ecosystems Management
MAC	Management Advisory Committee
MACC	Marine and Coastal Committee
MARPOL	International Convention for the Prevention of Pollution from Ships
MCCN	Marine and Coastal Community Network

MCS	Monitoring Control and Surveillance
MEY	Maximum Economic Yield
MOU	Memorandum of Understanding
MPA	Marine Protected Area
MSC	Marine Stewardship Council
MSE	Management Strategy Evaluation
MSP	Marine Spatial Planning
MSY	Maximum Sustainable Yield
MUM	Multiple Use Management
NAFO	North West Atlantic Fisheries Organisation
NER	Net Economic Return
NGO	Non government organisation
NPF	Northern Prawn Fishery
NPOA	National Plans of Action
NRMSC	Natural Resource Management Ministerial Council
NRSMPA	National Representative System of Marine Protected Areas
NSESD	National Strategy for Ecologically Sustainable Development
NSW	New South Wales
NT	Northern Territory
NWS	North West Shelf
NWSJEMS	North West Shelf Joint Environmental Management Study
OCS	Offshore Constitutional Settlement
OECD	Organisation for Economic Co-operation and Development
OPSAG	Oceans Policy Science Advisory Group
OSY	Optimum Sustainable Yield
PIC	Pacific Island Countries
QLD	Queensland
QMS	Quota Management System
RAG	Resource Assessment Group
RAP	Representative Areas Program
RDWG	Research and Development Working Group
RFMO	Regional Fisheries Management Organisation
RLIAC	Rock Lobster Industry Advisory Committee
RMP	Regional Marine Plan
RRFAC	Regional Recreational Fishing Advisory Committee
RSP	Regional Seas Programmes
SA	South Australia
SCFA	Standing Committee on Fisheries and Aquaculture
SCS	Scientific Certification Systems

SEA	Seafood experience Australia
SES	Social-ecological System
SESSF	Southern and Eastern Scalefish and Shark Fishery
SLED	Sea Lion Exclusion Device
SFR	Statutory Fishing Right
SOI	Southern Oscillation Index
SPS	Sanitary and Phytosnaitary
SSA	Seafood Services Australia
TAC	Total Allowable Catch
TBT	Tributyl Tin
TED	Turtle Excluder Device
TEP	Threatened, Endangered or Protected species
TRLF	Tasmanian Rock Lobster Fishery
UNCED	United Nations Conference on Environment and Development
UNCLOS	United Nations Convention of the Law of the Sea
UNEP	United Nations Environment Program
UNGASS	United Nations General Assembly Special Session
UNFAO	United Nations Food and Agriculture Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNFSA	United Nations Fish Stocks Agreement
VIC	Victoria
VMS	Vessel Monitoring System
WA	Western Australia
WAPC	Western Australian Planning Commission
WCPFC	Western and Central Pacific Fishery Commission
WCRLF	West Coast Rock Lobster Fishery
WECD	World Commission on Environment and Development
WRLDA	Western Rock Lobster Development Association
WSSD	World Summit on Sustainable Development
WTO	World Trade Organisation
WWF	World Wide Fund for Nature
www	world wide web

CHAPTER 1: INTRODUCTION

1.1 Background

Over the last decade there has been a rapid expansion of the international and regional fisheries policy agenda, fuelled largely by concerns over the state of the world's fish stocks and concomitant concerns over fishing practices. World fisheries production steadily increased after the Second World War, although the rate of capture fisheries production has been relatively stable since the mid 1980s, with aquaculture production significantly increasing. Distant water catches provided much of the increase in production until the early 1970s. These catches peaked in the late 1980s and declined from then as a proportion of world catch. The United Nations Food and Agriculture Organization (FAO) notes that in 2007 over half (52%) of the world's capture fish stocks were fully exploited, "and therefore producing catches which were at or close to maximum sustainable yield with no room for further expansion" (Food and Agriculture Organization 2009 p.7). Twenty eight per cent of fish stocks were either, over-exploited (19%), depleted (8%), or recovering from depletion (1%), with twenty per cent moderately exploited (Food and Agriculture Organization, 2009 p.7). Concerns over stocks, and impacts of, inter alia, over-fishing over-capacity, illegal unregulated and unreported (IUU) fishing, and flag of convenience (FOC) operations, has led to calls for fundamental changes in international fisheries management, including support for 'responsible fishing' practices. This has matched a broader international agenda supporting sustainable development of natural resources and the environment.

The concept of sustainable development gained widespread currency from the work of the 1987 World Commission on Environment and Development (WECD) and its report *Our Common Future* (World Commission on Environment and Development 1987). WCED had been charged by the United Nations General Assembly to propose long-term environmental strategies for achieving sustainable development by the year 2000 and beyond (Reid, 1995). WCED's Tokyo Declaration on 27 February 1987 (issued at the close of its final meeting) contained one of the most widely used definitions of sustainable development stating "such development can be defined simply as an approach to progress which meets the needs of the present without compromising the ability of future generations to meet their own needs." (World Commission on

Environment and Development, 1987, Annexe 2, Tokyo Declaration p.363). In Australia concerns relating to sustainable development led to the concept of Ecologically Sustainable Development (ESD) as a policy driver and parameter for decision-making. Therefore, Part One of the thesis refers to sustainable development and Part Two refers to Ecologically Sustainable Development (ESD).

The work of WCED had considerable influence in shaping international and national responses to environmental management. One outcome was the 1992 United Nations Conference on the Environment and Development (UNECD, the Earth Summit) held in Rio de Janiero. As Johnson (1995) outlines, following a resolution adopted by the United Nations General Assembly, UNCED was to develop strategies and measures to prevent continued environmental degradation of the planet. Actions needed to accomplish these objectives were contained in the *Rio Declaration* and *Agenda 21*, key outcomes from the conference. Conference outcomes also included the establishment of the United Nations Commission on Sustainable Development (CSD) to monitor and promote implementation of summit agreements such as the United Nations Framework Convention for Climate Change, and the Biodiversity Convention.

The Earth Summit II was held in New York 1997 – officially known as United Nations General Assembly Special Session (UNGASS). This was held to assess progress on the commitments made at Rio five years on. In 2002 the World Summit on Sustainable Development (WSSD) was held in Johannesburg, South Africa. The focus of WWSD was on actions to achieve effective implementation of sustainable development, to review progress to date, and to evaluate obstacles. The report to WWSD 2002 and the key outcomes from WSSD, are outlined in the Johannesburg Plan of Implementation. One outcome from WSSD 2002 was to encourage by 2010 the application of the ecosystem approach for sustainable development of oceans and fisheries (United Nations World Summit on Sustainable Development, 2002 p. 23).

Fisheries are a renewable resource if managed on a sustainable basis. While fish have been depleted by pre-industrial fisheries, it is however the advent of globalisation, industrialisation and uptake of technology (particularly after World War Two) which has affected fish stocks and marine ecosystems on a global scale, resulting in over-fishing and over-exploitation of marine resources (Caddy and Cochrane, 2001; Kaiser et al., 2005 pp. 401-405). In theory fisheries can be managed by the state or communities or groups of resource users. In most countries fisheries management is assigned to government departments or agencies. According to King (2007 pp. 273-301) the purposes of fisheries management is to ensure that catches from fish stocks are sustainable in the long-term. Historically the main aim of fisheries management has been to maximise sustainable yield and to ensure benefits to fishers and communities were maximised. Traditional fisheries management has focussed on the biology and distribution of stock species and the dynamics of fish stocks (stock structure and abundance); stock assessment methods Maximum Sustainable Yield (MSY); Catch per unit effort (CPUE); surplus production models; growth, mortality and age structured models); and a range of input controls on fishing effort and output controls on the catch.

Ecosystem Based Fisheries Management (EBFM) promises much and has attracted considerable interest. Ecosystem based fisheries management takes a new direction for fishery management by reversing the order of management priorities to start with the ecosystem rather than the target species (Pikitch et al. 2004).) The EBFM framework has developed on the principles and conceptual goals of the foundations for sustainable development, which aims at both human and ecosystem wellbeing. Support for alternative approaches to fisheries management have occurred following concerns over the global status of fish stocks. Many of the world's fish populations are fully or over-exploited and the ecosystems that support them have become degraded. EBFM is attractive as it addresses the limitations of single species management that ignores the wider ecosystem considerations (Caddy, 1999; Pikitch et al., 2004; Garcia and Cochrane, 2005).

The overall objective of EBFM is to sustain healthy marine ecosystems and the fisheries they support. To achieve this objective EBFM aims to avoid degradation of ecosystems as measured by indicators of environmental quality and system status; minimise the risk of irreversible changes to natural species assemblages and ecosystem processes; maintain long-term socio-economic benefits without compromising ecosystems; generate knowledge of ecosystem processes sufficient to understand the likely consequences of human actions; and where knowledge and understanding is limited, robust and precautionary fishery management measures should be applied (Pikitch et al., 2004).

The key aspects that underpin EBFM (see FAO, 2003; Ecosystem Principles Advisory Panel, 1999; Sissenwine and Mace, 2003; Ward et al., 2002; Pikitch et al., 2004) are:

- our capabilities are limited to the governance and management of human activities not marine ecosystems;
- societal choice and values are important factors in decision-making, and can affect governance and management outcomes;
- sustainability and resilience considerations are important to both marine ecosystems and humans systems;
- decision-making involves a number of different jurisdictional levels; and
- under conditions of uncertainty, it is prudent to apply the precautionary approach.

The key elements considered necessary for effective implementation of EBFM (see (FAO, 2003; Ecosystem Principles Advisory Panel, 1999; Sissenwine and Mace, 2003; Ward et al., 2002) include:

- stakeholder participation in governance and management arrangements at all jurisdictional levels;
- clearly defined goals and objectives, the development of performance indicators and reference points, monitoring and regular reporting;
- the allocation of effective user rights and a system of rights, rules and responsibilities that guide and control the human use of the marine environment;
- adaptive approaches to management – learning by doing, and then incorporating this new knowledge into decision-making – given the uncertainties in terms of both ecosystems and human systems;
- a wider range of both qualitative and quantitative information to be incorporated into decision-making processes, requiring a multi-disciplinary approach; and
- an incremental approach to implementation as EBFM is an ongoing and evolving approach to resource management, and some changes will take time.

The EBFM approache face the same problems as traditional fisheries management (such as over-fishing, over-capacity, government subsidies and IUU), but aims to deal with them in a more holistic manner, by placing them in a wider context, that takes into account both ecosystem characteristics and fisheries impacts, in decision-making processes and management measures (Garcia and de Leiva Moreno, 2003 p.15). Conceptually, therefore one would expect EBFM to be an effective approach. Successfully translating the concept to practice will, however, be dependent upon how EBFM is defined and implemented. Ecosystem complexities, ecological uncertainties, conflicts of interest, differing objectives between the competing users and stakeholders, and an increase in the number of participating stakeholders are critical factors. Two important questions are therefore:

- Is EBFM an improvement on current management approaches? and
- Can EBFM provide an effective framework for managing the environmental, economic and social issues?

1.2 Significance of the research

This project is timely and fills major gaps in existing knowledge regarding the management of fisheries. International debate over oceans and fisheries governance has been replicated in Australia with debates over fisheries management, marine environmental protection and coastal zone management with increasing calls for a more ecosystem-oriented approach to management. There is widespread agreement that previous management approaches have failed to effectively address the issues affecting oceans and fisheries (Charles, 2001; Garcia and Charles, 2007). In response, the introduction of EBFM has been proposed as an effective approach for managing such issues (Pikitch et al., 2004). Although sustainable developement has been more widely adopted, there does not appear to be a consensus regarding the adoption of EBFM, as highlighted by the international debates on the subject (Hartje et al., 2003; Korn et al., 2003). The literature outlines a number of different approaches to EBFM, each with particular guiding principles and mechanisms for implementation (FAO, 2003; Ecosystem Principles Advisory Panel, 1999; Sissenwine and Mace, 2003; Ward et al., 2002; Pikitch et al., 2004). The similarities and differences of these approaches need to be reviewed in order to identify the key aspect and elements that underpin EBFM and to then develop an agreed understanding of the approach. First, this is important to be able to assess the effectiveness of EBFM in dealing with oceans and fisheries issues; and second for its application to governance, and implementation by management, in any particular jurisdiction.

It is clear that attempts to manage under EBFM principles is challenging. To do so requires a systematic way of understanding and conceptualising interactions between ecological, economic and social systems. It also requires consideration of how tools and approaches designed to address and implement EBFM are incorporated into governance and management arrangements. There have been very few studies that have attempted to unpack EBFM, or to study the concept to its incorporation into governance and management arrangements, and then implementation at the fishery level. This research addresses this limitation by examining the introduction of EBFM into Australian fisheries. Australia has a reputation for innovation in fisheries management, and for effective and strong management.

Australia claims to be one of the first countries to implement an EBFM approach. There are three important aspects to be considered when assessing the implementation of EBFM at the national level:

- understanding the environmental, economic and social dimensions, as these set the context for fisheries governance and management;
- examining how EBFM principles have been incorporated into the governance and management framework, as this sets the parameters for fisheries management; and
- evaluating how EBFM has been implemented at the fishery level.

Two case studies have been used to illustrate how EBFM was being implemented at the fishery level. To examine possible impacts of scale and complexity two very different cases were chosen. One is a Commonwealth fishery managed by Australian Fisheries Management Authority (AFMA), in this case the Southern and Eastern Scalefish and Shark Fishery (SESSF) which is a mulit-species, milti-method, and multi sector fishery; the second a Western Australian fishery managed by the State Department of Fisheries, the West Coast Rock Lobster Fishery (WCRLF) which is a single species and single method fishery.

1.3 Research aims and objectives

The research is premised on the widely accepted position that managing under EBFM is complex. From this premise the thesis's proposition is that despite this complexity EBFM can be used as a framework for the management of oceans and fisheries.

The thesis has a primary aim: to examine the development and implementation of EBFM, provide an analysis which links biological components of fisheries with institutional arrangements and stakeholder interaction, through the development of a framework of analysis that incorporates these different elements of EBFM.

Related to this central proposition are two key objectives:

- the identification of the key concepts, aspects and elements of Ecosystem Based Fisheries Management; and
- the identification of the key aspects of governance and management under EBFM principles.

The second aim is the development of an integrated systems model under EBFM principles. This aim has two key objectives

- the development of a comprehensive biosocioeconomic subsystems model; and
- the development of a comprehensive governance and management subsystems model.

The third aim is to examine how EBFM has been applied in practice in Australian fisheries. This aim, has two key objectives:

- the identification and assessment of the key features of EBFM development and implemention in Australia; and
- the identification and assessment of the main challenges to implementation.

An important aspect of the scope of this research is to assess the integrated systems model empirically by applying it to the 'real world'.

1.4 Research design and approach

This research is shaped by the normal constraints of a PhD program, yet is also influenced by the scope of the topic. The focus on EBFM necessarily places constraints on the thesis. The relatively large and increasing literature on EBFM provides a complex field of concepts and approaches, yet actual experience in developing and implementing such an approach is more limited. A key aspect of the research design was the application of EBFM to current fisheries. A deliberate choice was made to focus on two cases. Alternative empirical examples could have been chosen and other example fisheries included, however the two example fisheries (SESSF and WCRLF) were studied in detail – nested within the national context of fisheries in Australia, and provide sufficient variables to evaluate the validity of the EBFM approach developed in the thesis.

The project's research design involves a structured focused comparative case study methodology (George, 1979). This approach adopts what has been termed the "most similar" systems approach (Roberts, 1978). As Roberts notes "where the problem is one of identifying and accounting for specific differences, selection of units of analysis which possess many similarities in terms of relevant variables makes easier the identification of variables which do differ" (Roberts, 1978). The "structured, focused comparison" approach (George, 1979) centres on (i) specification of the research problem and objectives (ii) case study research, and (iii) drawing out the theoretical implications of the case studies.

The research design utilised in the thesis draws on a three-stage research plan:

The first stage was a comprehensive literature review of the major issues for contemporary oceans and fisheries management. It examines the concepts and approaches and the international debates relating to EBFM. It also addresses governance and management of oceans and fisheries under EBFM principles. The literature review identifies the key aspects and elements that underpin EBFM principles, clarifies the relationship between them and other similar approaches, and challenges in implementing EBFM. The literature review also identifies the debates regarding the current status of fisheries and fisheries futures, and underlying causes regarding fisheries issues, which pose a challenge for fisheries management and the implementation of EBFM.

The second stage of the research plan centred on utilising a systems approach to develop an integrated systems model, under EBFM principles. This model aimed to unpack the environmental, economic and social dimensions of EBFM (components, characteristics, and drivers), and incorporated them within a qualitative biosocioeconomic systems model. The model also unpacked the governance and management dimensions in order to differentiate roles and responsibilities, and identify strategic and operational management approaches for implementing ESD and EBFM.

The third stage of the research plan was the investigation of how the EBFM principles have been incorporated into Australia's national fisheries governance and management arrangements. As noted above two case studies were used to illustrate how EBFM was being implemented at the fishery level.

The research utilised both primary and secondary data sources using a predominately qualitative research method. A range of published documentation was used (for example monographs; journal articles; fishery agency reports; research reports; international and Australian conference proceedings; international, regional and Australian conventions, agreements and acts; and international, regional and Australian organisations and institute web pages) This was further supported by two reviews undertaken a decade apart – 1998 and 2008 – of Australian fisheries under first ESD and in 2008 under EBFM principles (Sainsbury, Smith and Webb, 1998 and Webb and Smith, 2008). Both the 1998 and 2008 reviews were supported by the Fisheries Research and Development Corporation (FRDC).

The first review was initiated in 1998 following the identified need for a degree of consistency between fisheries jurisdictions to assist in achieving ESD objectives. One outcome of the 1998 review was the establishment of the FRDC ESD subprogram – itself to be an influential actor in the development of ecosystem-based management in Australia. The specific topics for review were the current status of the use of sustainability indicators; planned development in the use of sustainability indicators;

and future directions in the use of sustainability indicators, gaps and implications for research and development.

As a follow up FRDC initiated the second review, which was completed in 2008. The aim of this review was to provide an opportunity for a national snapshot of experiences and approaches across jurisdictions for the period from 1998 to 2006. The review's objectives were to:

1. Compare and contrast the scope, principles and criteria of fisheries ESD and EBFM.
2. Review and report on the major issues raised from the Environment Protection and Biodiversity Conservation (EPBC) strategic assessment process for ESD and EBFM, and implications for research and development.
3. Review the recent developments in fishery assessment methods, indicators and benchmarks used in Fisheries ESD and EBFM assessments and their state of development, and develop agreed directions on future assessment processes by end users (i.e. fishery regulators and DEWHA).
4. Review the response by fishery management agencies and Fisheries Research Advisory Board (FRABs) to the fisheries ESD and EBFM assessment methods, their status, development and future directions, and identify gaps and implications for research and development.
5. Identify possible bottlenecks for implementation and cost implications to fisheries.
6. Develop and deliver presentations and 'plain English' written summaries of the results of the review to Commonwealth and state fisheries departments, and other relevant Commonwealth agencies.

The 2008 review included a survey of Commonwealth and state fisheries. A survey was sent to each jurisdiction to a nominated representative for management, research, and industry. This survey was administered and distributed online. The purpose of the survey was to collect the relevant information to understand the current experience and management responses to fisheries ESD and EBFM in Australia for each fisheries jurisdiction (Commonwealth and the states and territories). During the course of the research for the 2008 review the consultation processes included significant interaction with the ESD subprogram as a key end user. Presentations were also made to all relevant agencies. Drafts of the final report were circulated to all fishery regulatory agencies and the Department of the Environment, Water and the Arts (DEWHA) for review, comment, and agreement for specific recommendations for inclusion in the final report. Final presentations and written material were made available through the ESD subprogram website.

This research has enabled the development of an integrated systems model under EBFM principles. The model, introduced in Chapter 2, termed biosocioeconomic (includes the environmental, economic and social dimensions), governance and management dimensions and subsystems. The biosocioeconomic dimensions set the context for governance and management (as it is within the ecosystem and human systems that oceans and fisheries issues occur). The model provides a framework for viewing the governance dimensions in terms of structure and function and as a means of reviewing policy initiatives in response to the oceans and fisheries issues and management actions. The model has been designed with the intention and capacity to be applied at any jurisdictional level as a means of viewing the circumstances at a particular level (or perspective) as well as in relation to other levels (or perspectives). The model will also be used to assess Australia's adoption of ESD and EBFM as a policy framework and governance responses and management arrangements at different scales; national, fishery agency, and individual fishery.

1.5 Thesis outline

The thesis has two parts. Part One investigates and discusses the conceptual and theoretical aspects and elements that underpin EBFM, and develops an integrated systems model to assist in understanding and implementing EBFM. Chapter 2 outlines the international response to the major oceans and fisheries issues. A review of the EBFM literature identified the key aspects and elements considered necessary for the implementation of EBFM. Chapter 3 discusses the environmental, economic and social context for governance and management. The biosocioecomic dimensions of the model are further developed to facilitate an understanding of the ecosystems and human systems, and the dynamic relations within and between them. Chapter 4 discusses the structure, function and jurisdictional roles and responsibilities of fisheries governance and management. It outlines the resulting multi-level and multi-institutional regime that are characteristics of fisheries management. The governance and management dimensions of the model are further developed highlighting the dynamic linkages, and key dependencies and relationships within the governance and management system. Chapter 5 discusses the important strategic and operational management considerations and decision-making methods and tools considered necessary for the successful implementation of EBFM. Part One essentially provides the underlying structure for Part Two of the thesis

Part Two investigates and assesses Australia's adoption and approach to ESD and EBFM; the governance and management of ocean and fisheries under EBFM principles; and implementation of EBFM at the fishery level. The systems model developed in Part One of the thesis will be applied to Australian oceans and fisheries at the national, fishery agency and individual fishery levels. Chapter 6 discusses Australia's position and responsibilities within international, regional and bilateral forums. It outlines the adoption and development of a national ESD and EBFM policy framework, particularly as it relates to oceans and fisheries governance and management; the key environmental, economic and social issues in Australia and the policy initiatives developed in response to these issues; and the main governance and management institutions responsible for oceans and fisheries, and administering ESD and EBFM. These governance and management arrangements set the parameters for fishery management. Chapter 7 outlines the environmental, economic and social context for Australian fisheries; and the key management considerations (management arrangements and processes and measures) regarding Commonwealth, state and territory managed fisheries are discussed. Results from two fisheries reviews of the strategic and operational management under ESD and EBFM principles in Australia is presented. Chapter 8 illustrates the implementation of EBFM by the Australian Fisheries Management Austhority and a case study fishery, the Southern and Eastern Scalefish and Shark Fishery (SESSF); and by the Western Australian Department of Fisheries and a case study fishery, the Western Rock Lobster Fishery (WCRLF).

Chapter 9 is the conclusion to the thesis which refers to the thesis's aims and objectives; assesses the development and application of the integrated systems model; reviews implementation of EBFM in Australian fisheries by reference to the case studies; and considers directions and recommendations for future application of EBFM.

CHAPTER 2: SUSTAINABLE DEVELOPMENT AND ECOSYSTEM BASED FISHERIES MANAGEMENT

2.1 Introduction

There are a number of factors that have encouraged moves toward sustainable development and Ecosystem Based Fisheries Management (EBFM). Increasing pressure of human activities on ecosystems continues to pose threats to the terrestrial and marine environment, with sectoral approaches to management recognised as failing to take into account the effects of multiple users and uses, and their associated and cumulative impacts. As a result, approaches that integrate governance and management encompassing environmental, economic and social components are being promoted. As Lackey (1998) notes these issues have become mainstream in political and community domains, representing a continuing evolution of social values and priorities. The introduction of sustainable development and EBFM may be viewed as part of a continuum of responses to environmental and resource management issues that were first raised in the 1960s. During the last two decades many international initiatives (regional arrangements and national policies) have been developed to address ecosystem and human system sustainability. The concept of sustainable development emerged in the 1980s to describe a new framework for development aimed at achieving economic and social development, while maintaining long-term integrity of ecological systems. The EBFM approach shifts the focus from single target species fisheries management to include the broader ecosystem and human system considerations. These international initiatives provide a conceptual basis and guiding principles for the implementation of sustainable development and EBFM at regional and national levels.

The purpose of this Chapter is to provide a background to the development of sustainable development, Ecosystem-Based Management (EBM) and EBFM. This will be followed by an outline of the major international initiatives, sustainable development and Ecosystem Based Fisheries Management approaches (with EBFM nested as one sector focus within Ecosystem-Based Management). The discussion of development of the EBFM approach includes the international dimensions; the EBFM concept and overarching goals and objectives; and the key aspects and elements that underpin EBFM. The challenges for implementing EBFM will be briefly outlined. This will be followed by a discussion on the current debates regarding the status of fisheries; and the key issues which include overfishing, over-capacity, government subsidies, and illegal, unreported and unregulated fishing. The final section will outline a systems approach and an integrated systems model under EBFM principles, to be further developed in subsequent Chapters of Part One of this thesis. There are various terms that are used in relation to Ecosystem-Based Management (EBM), these include Ecosystem Management Approach (ESM). There are also various terms that are used in relation to the EBFM approach including the Ecosystem Approach to Fisheries (EAF) and the Ecosystem Approach (EA or EsA). As Garcia et al. (2003, p. iv) point out the meaning of the terms EBM, EBFM and EAF are still not universally defined, but will be discussed in Section 2.3, Section 2.4, and Section 2.5.

2.2 Sustainable development: concept and practice

2.2.1 Background

The sustainability debate and the emergence of the environment movement in the 1960s and 1970s, was in response to growing concerns over the impact of development on the environment. The publication of *Silent Spring* outlined the effects of crop dusting with insecticides and the destruction of wildlife (Carson, 1962). This was followed by other significant publications such as *The Historical Roots of our Ecological Crisis* (White, 1967) and *The Limits to Growth* (Meadows et al., 1972) which challenged traditional assumptions that the natural environment could provide resources for unlimited development and continuing population growth. In 1972 the first United Nations Conference on the Human Environment was held in Stockholm, and focused on the link between environmental problems and economic development. In 1980 the World Conservation Strategy was initiated by the International Union for Conservation of Nature and Natural Resources (IUCN), the United Nations Environment Program (UNEP), and the World Wide Fund for Nature (WWF). The strategy aimed to advance sustainable development through the conservation of the environment as a living resource base. It also highlighted the fact that economic development relies on the maintenance of the earth’s living resources.

Awareness and understanding of the impacts of unsustainable natural resource use on ecosystems and biodiversity continued to evolve, as demonstrated by the outcomes from major international initiatives. In 1987 the World Commission on Environment and Development (WCED) published *Our Common Future* (WCED, 1987), which defined strategies for achieving sustainable development and addressing the interlinked environment and development challenges. This was followed by the United Nations Conference of the Environment and Development (UNECD) in 1992, which aimed at further developing strategies to prevent continued environmental degradation. One outcome was *Agenda 21*, which was seen as a blueprint for action to accomplish global sustainable development and to address the impacts of human activities on the environment. The 2002 World Summit on Sustainable Development (WSSD) focused on progress since UNECD 1992, based on the actions outlined in *Agenda 21*. It was reported that human activities were continuing to have an increased impact on the integrity of ecosystems which provide essential resources and services for human wellbeing. To reverse these trends the Johannesburg Plan of Implementation (JPOI) 2002 outlined the necessary actions and suggested timelines for implementation, at national and regional levels. The key features and outcomes from these three initiatives as they relate to oceans and fisheries are outlined below.

2.2.2 The World Commission on Environmental Development (WECD)

The concept of sustainable development was introduced to the world in 1987, with the publication by WCED of its report *Our Common Future* (Reid, 1995). The Commission had been asked by the United Nations General Assembly to propose long-term environmental strategies for achieving sustainable development by the year 2000 and beyond; and to formulate a global agenda for change based on three objectives:

- to re-examine the critical environment and development issues and to formulate realistic proposals for dealing with them;
- to propose new forms of international co-operation on these issues that would influence policies in the direction of needed changes; and
- to raise levels of understanding and commitment to action by individuals, voluntary organisations, businesses, institutes and governments (WCED, 1987 p. ix).

At the close of its final meeting in Tokyo, the WCED issued the Tokyo Declaration containing the most widely used definition of sustainable development. “Such development can be defined simply as an approach to progress which meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987 p. 363).

The WCED noted there had been a growing realisation that economic development and environmental issues are interlinked; that many forms of development erode resources and cause environmental degradation; and that economic development relies on these environmental resources. Sustainable development is not a fixed state, but a process of change in which the exploitation of resources, the direction of investments, the orientation of technology, and institutional change are made consistent with future and present needs. One of the important policy directions to which the Commission focused on was species and ecosystems. As the conservation of living natural resources, plants, animals, and micro-organisms, and non-living elements of the environment on which they depend was considered crucial for development. The major issues identified were those of disappearing species and threatened ecosystems. In response, a network of protected areas was recommended (WCED, 1987 p. 13). Aspects that relate to oceans and fisheries and their governance were discussed in Chapters 10 and 12 of the WCED report and are briefly outlined below.

Our Common Future Chapter 10: Managing the Commons

Traditional forms of national sovereignty were being challenged by the realities of ecological and economic interdependence, particularly shared ecosystems, and those of the global commons outside national jurisdictions. The oceans were seen as important as they cover over 70% of the planet's surface and play a critical role in maintaining life support systems, such as moderating the climate, and sustaining animals and plants, as well as providing a sink for by products of human activities. The oceans were considered under threat from over-exploitation, pollution and impacts from land-based development. The Commission proposed a number of measures with regard to oceans and fisheries management:

- strengthen the capacity for national action such as:
    - reviewing legal and institutional requirements for integrated management of Exclusive Economic Zones (EEZs) and for international co-operation
    - reducing over-exploitation of fisheries in coastal and offshore waters

- reducing pollution discharging into critical marine habitats
- strengthening national research and management
- producing an inventory of coastal and marine resources;

- improve fisheries management by:
  - strengthening national research and management
  - introducing effective conservation and management measures to deal with over-exploitation of marine resources
  - managing marine resources on a sustainable basis;
- reinforce co-operation in semi-enclosed and regional seas through:
  - the UNEP Regional Seas program, which brings governments together to develop a flexible legal framework within which further agreements can be negotiated; and
- strengthen control of ocean disposal of hazardous and nuclear wastes through agreed Conventions such as:
  - The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Dumping Convention) which came into force in August 1975
  - The Convention for the Prevention of Marine Pollution from Land-Based Sources (Paris Convention) was ratified in 1978 (WCED, 1987 pp. 265-274).

The WCED suggested that management of the oceans would require institutional and policy changes, and outlined three imperatives: effective global management regimes (because of the underlying unity of the oceans); regional management (for shared resources a characteristic of regional seas); and effective national and international co-operation regarding land-based threats (WCED, 1987 p. 264). Conceptual guidelines for proposed institutional and legal changes at the national level were outlined in Chapter 12.

Our Common Future Chapter 12: Towards Common Action

Environmental protection and sustainable development must be an integral aspect for institutions and organisations. Chapter 12 provides conceptual guidelines for institutions and organisations. Policy development requires an understanding of the ecological issues, and consideration of the economic and social components, with policy decisions supported by a legal framework. The Commission identified six priority areas for institutions and organisations at different jurisdictional levels:

- getting at the sources:
    - international bodies and agencies should ensure their programs encourage and support sustainable development, and improve co-ordination and co-operation
    - regional organisations need to integrate environmental considerations into their goals and activities and deal with trans-boundary issues
    - national governments need to make agencies directly responsible and accountable for development that is economically and ecologically sustainable;
- dealing with effects:
    - at an international level the United Nations Environment Programme (UNEP) is the principal source of environmental data, assessment and reporting. It acts as a principal advocate and agent for change and international co-operation on critical environment and natural resource protection issues
    - nationally governments should reinforce the role and capacity of environmental protection and natural resource management agencies;
- assessing the global risks:
    - at all jurisdictional levels the capacity to identify, assess and report on risks of irreversible damage to natural systems must be reinforced and extended;
- making informed choices:

  - the transition to sustainable development will require a range of public policy choices that are inherently complex and politically difficult. Requiring widespread support and involvement from an informed public and stakeholders (government and non-governmental organisations, scientific community, and industry) and participation in developing, planning, decision-making, and implementation processes;

- providing legal means:
  - international and national laws need to be reviewed so they do not become outdistanced by the accelerating pace and expanding scale of impacts on the ecological environment
  - ways need to be found that recognise and protect the rights of present and future generations
  - strengthen procedures for avoiding or resolving disputes regarding environment and resource issues; and
- investing in the future:
  - prevention of environmental degradation is more cost effective than restoration (WCED, 1987 pp. 313-342).

2.2.3 United Nations Conference on the Environment and Development

The purpose of the 1992 United Nations Conference on the Environment and Development (UNECD), held in Rio de Janeiro was to develop strategies and measures to prevent continued environmental degradation of the planet. According to Johnson (1993), the mandate given to the Conference called for a global meeting to devise integrated strategies that would halt and reverse the negative impact of human behaviour on the physical environment, and promote sustainable development. The Earth Summit promoted international co-operation for global agreements; development of a global partnership in planning for environmental protection, and social and economic development; and viewed environmental protection not as an obstacle to economic growth but a vital partner, and an essential component. Outcomes from the Summit included the *Rio Declaration* and *Agenda 21.*

The Rio Declaration on Environment and Development

The Rio Declaration (United Nations Conference on the Environment and Development, 1992a) reaffirmed the Declaration of the United Nations Conference on the Human Environment adopted at Stockholm in 1972. The goal was to establish a new and equitable global partnership through new levels of co-operation among states, key sectors of society and people. The Declaration aimed at working towards international agreements, which respected the interests of all, and to protect the integrity of the global environment and developmental system. The Declaration also recognised the integral and interdependent nature of the Earth. The Declaration proclaimed twenty seven principles articulating the basis for international agreement, and guidance upon which international governance could be based.

Agenda 21

Agenda 21 (United Nations Conference on the Environment and Development, 1992b) was seen as a blueprint for action into the twenty first century by governments, United Nations organisations, development agencies, non-governmental organisations, and independent sector groups, in every area in which humans impact on the environment, and suggests actions needed to accomplish global sustainable development. That it should provide a framework and instruments, which would guide the world community on an ongoing basis in its decisions relating to the issues of the environment and development, which would determine the future of the planet (Johnson 1993). The aspects that relate to oceans and fisheries and their governance are described in Chapter 17, Chapter 35, and Chapter 39 of *Agenda 21*.

Chapter 17 Protection of the oceans, all kinds of seas, including enclosed and semi-enclosed seas, and coastal areas and the protection, rational use and development of their living resources

The marine environment includes the oceans, all seas and adjacent coastal areas, which forms an integrated whole that is an essential component of the global life-support system; and a positive asset presenting opportunities for sustainable development. International law, as reflected in the provisions of the United Nations Convention on the Law of the Sea (UNCLOS), sets forth rights and obligations of states, and provides the international basis upon which to pursue the protection and sustainable development of the marine and coastal environment and its resources. This requires new approaches to marine and coastal area management and development, at all jurisdictional levels. These approaches need to be integrated in content, and precautionary and anticipatory in ambit, as reflected in the following programme areas:

- Programme A: Integrated management and sustainable development of coastal and marine areas, including exclusive economic zones;
- Programme B: Marine environmental protection;
- Programme C: Sustainable use and conservation of marine living resources of the high seas;
- Programme D: Sustainable use and conservation of marine living resources under national jurisdiction;
- Programme E: Addressing critical uncertainties for the management of the marine environment and climate change;
- Programme F: Strengthening international and regional, co-operation and co-ordination; and
- Programme G: Sustainable development of small islands (United Nations Conference on the Environment and Development, 1992b pp.147-165).

Chapter 35: Science for sustainable development

This Chapter focuses on the role and use of the sciences in supporting sustainable development and decision-making processes. Lack of scientific understanding should not be used for postponing actions, and under these circumstances the precautionary approach should apply. The programme areas included:

- strengthening the scientific basis for sustainable management;
- enhancing scientific understanding;
- improving long-term scientific assessment; and
- building up scientific capacity and capability (United Nations Conference on the Environment and Development, 1992b pp. 257-263).

Chapter 39: International legal instruments and mechanisms

This Chapter outlines the aspects of universal, multi-lateral, and bilateral treaty-making processes that should be taken into account, such as further development of international law on sustainable development, with attention to the balance between environmental and developmental concerns. It seeks to clarify and strengthen relationships between existing international instruments, or agreements, and take into account the special needs of developing countries. It argues that the overall objectives of the review and development of international environmental law should be to evaluate and promote efficacy of the law; integration of environment and development policies through effective international agreements, or instruments; and take into account both universal principals and in particular the differentiated needs and concerns of all countries. Some specific objectives included the following:

- enhancing efficacy of international law by setting priorities for future law-making on sustainable development at the global, regional, and sub-regional level, in particular the integration of environmental and developmental concerns;
- support effective participation of all countries in the negotiation, implementation, review and governance of international agreements or instruments;
- promote the gradual development of universally and multi-laterally negotiated agreements or instruments, and international standards for protecting the environment that take into account the different situations and capabilities of countries;
- should trade policy measures be found necessary for enforcement of environmental policies, certain principles and rules should apply;
- improve the effectiveness of institutional, mechanisms and procedures for the administration of agreements and instruments; and
- identify and prevent potential conflicts, particularly between environmental and social/economic agreements or instruments, with a view to ensuring that such agreements or instruments are consistent (United Nations Conference on the Environment and Development, 1992b pp. 281-283).

Although, *Agenda 21* bears the marks of a negotiated document, commentators such as Johnson (1993) acknowledged that it does try to integrate environment and development issues. *Agenda 21* attempts to specify what action is needed to reconcile development with environmental concerns, although it is not legally binding.

2.2.4 World Summit on Sustainable Development

In preparation for the 2002 United Nations World Summit on Sustainable Development (WSSD) held in Johannesburg, South Africa, the Co-Chairs' Bernal, et al. (2001 p. 10) reported some major problems and constraints for achieving sustainable development, such as the fragmentation and the lack of co-ordination and harmonisation of international agreements, and the lack of appropriate compliance and enforcement mechanisms for international instruments. The focus of the 2002 World Summit on Sustainable Development (WSSD) was to review progress in achieving sustainable development, since UNECD 1992, based on the program of action as outlined in *Agenda 21* and to evaluate obstacles to progress (United Nations, 2002 pp. 2-3). The development of a ten year framework of programs in support of regional and national initiatives for changing unsustainable patterns of consumption and production, reducing resource degradation and pollution and wastes was encouraged. Key actions are outlined in the Johannesburg Plan of Implementation of the World Summit on Sustainable Development (United Nations, 2002).

Johannesburg Plan of Implementation

It was argued that human activities were continuing to have an increased impact on the integrity of ecosystems which provide essential resources and services for human well being. Managing natural resources on an integrated and sustainable basis was essential for development. To reverse the current trend in natural resource degradation as soon as possible, it would be necessary to implement strategies at the national, and where appropriate the regional level to protect ecosystems as well as strengthening regional, national and local capacities. Biodiversity was considered important, therefore achievement of a significant reduction in the current rates of loss of biological diversity was required by 2010 (United Nations, 2002 pp. 20, 35).

The requirements and actions for sustainable use, conservation and management of oceans and fisheries would require effective co-ordination and co-operation at all jurisdictional levels. This included the establishment by 2004 of a regular process under the United Nations for global reporting on, and assessment of the state, of the marine environment, including socio-economic aspects; and improved scientific understanding and assessment of marine and coastal ecosystems as a basis for decision-making. A number of other actions under the plan were as follows:

- in accordance with Chapter 17 of *Agenda 21* promote conservation and management of oceans through actions at all jurisdictional levels, giving due regard to the relevant international instruments to:
  - maintain productivity and biodiversity of important and vulnerable marine and coastal areas, including those within and beyond national jurisdictions;
  - develop national, regional and international programs for halting the loss of marine biodiversity;
  - implement the work program as outlined in the Jakarta Mandate on the Conservation and Sustainable Use of Marine and Coastal Biological Diversity;
  - develop and facilitate the use of diverse management approaches and tools, including the ecosystem approach;
  - the establishment of marine protected areas consistent with international law and based on scientific information, including representative networks by 2012;
- advance the implementation of the Global Programme of Action for the Protection of the Marine Environment from land-based activities, and the Montreal Declaration of the Protection of the Marine Environment form Land-based Activities, with an emphasis on the following:
  - during the period 2002-2006 attention to municipal waste water, nutrients and the physical alteration and destruction of habitats;

  - make every effort to achieve substantial progress by the next Global Programme of Action conference in 2006, to protect the marine environment from land-based activities;

- to achieve sustainable fisheries required the following actions:

  - ratify or accede to, and effectively implement international fisheries agreements or arrangements, including the United Nations Food and Agriculture Organisation (FAO) Code of Conduct for Responsible Fisheries 1995;

  - encourage the application by 2010 of the ecosystem approach;

  - maintain or restore depleted fish stocks to levels that can produce the maximum sustainable yield, and for depleted stocks on an urgent basis, and where possible by 2015;

  - develop and implement at the national and regional levels, the International Plans of Action (IPOAs) by the agreed dates, including the prevention of illegal, unreported and unregulated fishing (IUU) by 2004, and the management of fishing capacity by 2005;

  - eliminate subsidies that contribute to over-capacity and illegal, unreported and unregulated fishing; and

- enhance maritime safety and protection of the marine environment from pollution such as ship's toxic anti fouling paints; and the introduction of invasive species from ship's ballast water (United Nations, 2002 pp. 22-27).

2.2.5 The Commission for Sustainable Development

The Commission for Sustainable Development (CSD) was established by the UN General Assembly in December 1992. The Commission is responsible for reviewing progress of the implementation of *Agenda 21* and the Rio Declaration on Environment and Development; as well as providing policy guidance for the Johannesburg Plan of Implementation (JOPI) at the all jurisdictional levels. The CSD meets annually, and at the eleventh session a multi-year program of work from 2004/2005 to 2016/2017 was decided upon, which was organised on the basis of seven two year cycles, with each cycle focusing on a selected thematic cluster of issues. Oceans and seas, and marine resources are scheduled for the years 2014/2015, and will include the following cross cutting issues: changing unsustainable patterns of consumption and production; protecting and managing the natural resource base of economic and social development; and sustainable development in a globalising world (United Nations Department of Economic and Social Affairs Division for Sustainable Development, 2009).

2.3 Ecosystem Based Management

2.3.1 Ecosystem Based Management: the concept

An approach that builds on the sustainable development and considers ecosystems together with human activities which affect them is Ecosystem-Based Management (EBM). Ward et al. (1997 pp.11-12) argued in order to protect environmental quality and biodiversity in the long-term (especially under conditions of increasing economic development and other social pressures), requires integrated management which maintains ecosystem integrity, and recommended management of the environment within an Ecosystem-Based Management (EBM) framework. As discussed by Hartje et al. (2003 p.12) traditional resource management often viewed environmental resources as inputs into the production of economic goods and services for human consumption, and under the control of humans. Whereas, EBM acknowledges ecosystems are complex and dynamic, and that protection of ecosystem attributes and biological diversity, are critical for the continued provision of these goods and services now and into the future.

There is an extensive literature on the subject of EBM, therefore the number of EBM approaches reviewed for discussion, have been limted to the following key sources:

- The United Nations Convention on Biological Diversity (CBD) 1992, based on the revised Malawi principles as developed at the Isle of Vilm workshop in October 2002 and outlined by Korn et al. (2003) *Report of the International Workshop on the Further Development of the Ecosystem Approach*.
- Mangel et al. (1996), *Principles for the conservation of wild living resources*. Between 1992-1994 as part of the Marine Mammal Commission project on Living Resource Conservation, research scientists and resource managers were consulted to obtain an authoritative global overview of principles for the

conservation of wild living resources. The term “living resources” refers to aquatic and terrestrial animals and plants that are free-living, i.e. those not intensively farmed or cultivated. It includes marine mammals, marine fishes, other aquatic vertebrates, invertebrates, and plants.

- Grumbine (1994) *What is ecosystem management?* In order to identify the dominant themes of ecosystem management, Grumbine undertook a literature review of peer reviewed journals, books, and government publications, as well as from a broad spectrum of disciplines including conservation biology, resource management, and public policy.
- Christensen et al. (1996) *The Report of the Ecological society of America Committee on the Scientific Basis for Ecosystem Management* (a report to the Ecological Society of America Committee on the scientific basis for ecosystem management).

A summary of the overarching goals, objectives and key challenges for EBM as outlined by these authors is presented below. According to Hartje et al. (2003 pp.12) the Convention on Biological Diversity (CBD) approach is a strategy for integrated management that promotes conservation and sustainable use in an equitable way and supports the following three objectives: the conservation of ecosystems; sustainable use of ecosystem goods and services for human purposes; and equitable sharing of benefits. The issue of how all three objectives can be managed simultaneously and with equal priority is the challenge. Different institutions focus on particular objectives, for example conservation or sustainable use. Meeting Convention on Biological Diversity (CBD) objectives would, therefore require institutions to widen their perspective to include both conservation and sustainable use views.

Mangel et al. (1996) argued the relationship between humans and nature should be such that the viability of all biota and the ecosystems they are part of are maintained, as well as allowing human use and benefits from such use. The challenge is determining the appropriate balance between the health of resources and ecosystems and the health and quality of human life. Such a balance in their view required an understanding of a broad range of issues. Grumbine’s (1994) review of the literature suggests the overall goal of ecosystem management is sustaining ecological integrity by reducing the biodiversity crisis. This is to be achieved through maintaining viable populations of all native species in situ; represented within protected areas with all native ecosystem types and across their natural range of variation; maintaining evolutionary and ecological processes; and managing over periods of time long enough to maintain the evolutionary potential of species and ecosystems. As well as acknowledging the role that people have to play by accommodating human uses and occupancy within the above constraints. The success of ecosystem-based management is dependent upon reconciling the relationship between the new goal of protecting ecological integrity and the old view of ecosystems providing goods and services for humans.

As described by Christensen et al. (1996) ecosystem management regards intergenerational sustainability as a precondition, and establishes measurable goals and processes necessary for sustainability outcomes. An ecosystems approach is neither anthropocentric nor biocentric, but acknowledges the importance of human needs while confronting the reality and capacity of the natural world to meet those needs in perpetuity has limits, and depends on the functioning of ecosystems. However, one particular obstacle to an ecosystem approach is that of public perception, where often the immediate economic and social value of renewable resources outweighs the risk of future ecosystem damage. The goal of ecosystem management is to overcome this and other such obstacles.

Ecosystem Based Management: some key issues

Although there is general agreement with the EBM concepts, principles and guidelines there is no general agreement in terms of management approaches and outcomes. The aim of EBM is to codify the basic elements of holistic natural resource management with an emphasis on biodiversity conservation. The adoption of these principles raised an international debate on its feasibility in terms of logical consistency and its value as a practical guide for implementation. In general many of the key issues identified in the reviews often focused on implementation of the ecosystem approach (Hartje et al., 2003 p.7). Korn et al. (2003 pp. 21-24) identified a number of key points and issues, regarding the implementation of the ecosystem approach, some of these are presented in table 2.3.1.

Table 2.3.1: Summary of key issues.

Key Issues	Comments
1. Further clarification of the concept of the EBM approach	There are different stakeholder perceptions regarding EBM. The relation to sustainable use concept needs further clarification. It should be made clear whether EBM is a framework or a modus operandi for ecosystem management. Specific terms used in the principles need to be defined.
2. Relation of the EBM approach to other concepts and approaches	EBM is not seen as in competition with other integrated management approaches. EBM might be seen as a codification of already existing integrated sector management approaches and EBM should benefit from synergies with other integrated sector approaches.
3. Improving the understanding of EBM principles	The general principles are supported, but there are difficulties explaining and applying them. A hierarchical or logically sequenced order was suggested for the principles, and to reduce the number by grouping them. The principles should be checked for consistency and redundancy.
4. Improving the implementation of EBM	A question was if the principles are a package, whether there was enough flexibility to apply some principles now and add others over time. The principles of EBM should be seen as interlinked and complementary, and in some cases a stepwise approach is useful.
5. Societal choice	There were uncertainties on the meaning of societal choice. Societal choice has to be seen in the context of governance. Some studies concluded that early involvement of stakeholders is necessary. Effective information management and open decision-making processes are essential for active public participation. There is often a lack of stakeholder motivation to participate in decision-making processes if the negotiations are long term, complex, and include trade offs between competing interests.

These key issues, and the lessons learned from the case studies, also apply to the application of EBFM, which is the subject of the next section.

2.4 The development of an Ecosystem Based Fisheries Management approach

According to Dyoulgerov (2000 p. 331) there is a well-defined body of international environmental law, and global legal instruments that deal with the marine environment. These include the 1982 United Nations Law of the Sea Convention (UNLOSC) (United Nations 1982) and the 1992 United Nations Convention on Biological Diversity (CBD) (United Nations 1992).

2.4.1 Law of the Sea Convention and the Convention on Biological Diversity

The 1982 United Nations Law of the Sea Convention (UNLOSC) provides a framework to regulate all aspects of the uses of the sea, and the conservation of the marine environment. The 1992 United Nations Convention on Biological Diversity (CBD) promotes the conservation of biological diversity and the sustainable use of its components. UNLOSC and the CBD provide a framework within which governance of the marine environment functions as part of a dynamic, interdependent, and complementary system of hard and soft law.

United Nations Law of the Sea Convention (UNLOSC)

UNLOSC provides a comprehensive framework for managing ocean stresses and lays down strong and binding obligations to protect and preserve the marine environment, including rare or fragile ecosystems and the habitat of marine species; and conservation of marine living resources. While not specifically addressing EBFM, its principles, provisions and mechanisms have been elaborated through other specialised legal instruments to support an ecosystems-based and precautionary approach to sustainable ocean use. UNLOSC also establishes a comprehensive framework for use and development of the oceans regarding the rights and obligations of states in the various zones; dispute settlement, compliance, and enforcement; international co-operation opportunities; and institutional support (Kimball, 2001 pp. 2, 7). The Convention has been supplemented by two implementing agreements – the 1994 Agreement relating to the implementation of Part XI, which clarifies many of the Convention’s deep seabed mining provisions adopted in 1982; and the 1995 Agreement relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Species (United Nations Fish Stocks Agreement or UNFSA).

United Nations Convention on Biological Diversity

The CBD’s comprehensive approach to species, ecosystems, and genetic diversity, and its endorsement of an ecosystems approach to biodiversity conservation, strengthen the impetus for an ecosystem-based approach to marine conservation (Kimball, 2001). One of the first substantive sectors to be considered by CBD was marine and coastal biodiversity. The 1995 Jakarta Mandate specifically addressed the relationships between conservation and fishing activities and established coastal and marine biodiversity as one of the first substantive sectors to be considered by the Convention (Tsamenyi and McIlgorm, 1999 p. 24). Under the mandate the following five major programs were identified: integrated marine and coastal management; sustainable use of marine and coastal living resources (including coral reefs and coral bleaching); marine and coastal protected areas; mariculture; and alien species. The Parties also agreed to the following general approaches in addressing the above programs. These were applying the precautionary approach; facilitating interactions with relevant organisations and agencies; facilitating capacity building and technology transfer, (including knowledge of local and indigenous communities); community and user-based approaches; use of the Convention clearing house mechanisms; and national reporting of the Parties (Tsamenyi and McIlgorm, 1999 p. 24).

2.5 Ecosystem Based Fishery Management

The Ecosystem Based fisheries Management (EBFM) approach builds on sustainable development and EBM (as briefly outlined above), and has support at the international level. While the terms EAF and EBFM are often used interchangeably, and as Garcia et al. (2003 p.6) suggest, although there are overlaps and in practice appear to be converging, it should be noted that there are differences. The term EAF was adopted by the FAO Technical Consultation on Ecosystem-based Fisheries Management by the Reykjavik Conference 2002. As defined by the FAO (2003, p. 6) EAF is a means to implement sustainable development concepts into fisheries by addressing both human and ecological well-being (by focusing on ecosystem structure and function and on providing food and income/livelihoods for humans by managing fisheries activities). EAF recognises the broader uses and users of the marine environment. According to Garcia et al. (2003 p. 6) the term EBFM places the focus for management on the users and what is managed is the economic activity. This term did not meet with consensus at the Reykjavik Conference, due to concerns that environmental considerations might be given precedence over socio-economic and culture aspects.

2.5.1 Ecosystem Based Fisheries Management: the international dimension

The international community developed a framework of international instruments and agreements to manage fisheries on a sustainable basis. This was in order to halt the over-exploitation of living marine resources and their supporting ecosystems; as well as allowing for sustainable use to provide continuing human, social and economic benefits, for current and future generations (Cochrane and Doulman, 2005). Some international instruments are directly aimed at fisheries, others are of general application, with a potential to influence the fishing industry. These fall into two broad categories: Conventions, that are binding (hard law) on Parties to them, or non-binding (soft law) instruments, which are the resolutions of declarations by international organisations and some larger non-government organisations. Although not legally binding, they have a moral and political force that may become the basis for binding instruments. The major trend in instruments is a move from general objectives in the currently binding agreements, to more specific constraints and management methods in the subsequent non-binding instruments (Aqorau, 2003; Tsamenyi and McIlgorm, 1999). Since the 1992 UNECD, the pace of development of these binding and voluntary instruments has increased. A number of international events have contributed to the progressive emergence of instruments (as listed below) that support sustainable development and an EBFM approach.

- 1970 FAO Technical Conference on Marine Pollution and its Effects on Living Resources and Fishing, provided an early expression of the concern for the impact of land-based sources of pollution and degradation on fisheries.
- 1972 FAO Technical Conference on Fishery Management and Development stressed both the problems of over-fishing and of environmental degradation from non-fishery sources. It also called for new management approaches based on precaution and on addressing multi-species problems. It proposed to integrate the new fisheries management within the broader framework of ocean management.
- 1972 World Conference on Human Environment, the natural resources of the earth, including the air, water, land, flora and fauna and especially representative

samples of natural ecosystems, must be safeguarded for the benefit of present and future generations through careful planning or management, as appropriate (Principle 2).

- 1973 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) aims to ensure that international trade in specimens of wild animals and plants does not endanger their survival.
- 1980 Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) is usually considered a precursor of the ecosystem approach to fisheries.
- 1982 United Nations Convention on the Law of the Sea (UNLOSC) under articles 61 and 62 deals with the conservation, management and utilisation of living marine resources within the Exclusive Economic Zones (EEZ).
- 1987 World Commission on Environment and Development (WCED) further developed the concept of sustainable development.
- 1992 United Conference on Environment and Development (UNCED). The Conference led to the adoption of a number of conventions and agreements of relevance to EBFM, such as the Rio Declaration and *Agenda 21*.
- 1992 United Nations Convention on Biological Diversity (CBD) elaborates the core principles of multiple-use management of biodiversity and adopted an ecosystem approach. The CBD recommends establishing a system of marine protected areas (MPAs), considered an essential measure for conserving biodiversity. Biodiversity is important from an EBFM point of view as it relates to resilience, the capacity to resist an impact or return to original conditions after the impact has been removed.
- 1993 FAO Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas. It is intended to provide an instrument for countries to take effective action, consistent with international law, to ensure compliance with applicable international conservation and management measures for living marine resources of the high seas.

- 1995 Jakarta Mandate on Marine and Costal Biological Diversity elaborated further on the “ecosystem approach” adopted by the CBD. Focusing on protected areas, applying the precautionary approach, using all relevant knowledge (scientific, indigenous knowledge), and stakeholders’ participation. It aims, *inter alia*, at integrated management, and development of the ecosystem approach; assessment and minimisation of mariculture impacts; and the understanding of causes and impacts of the introduction of alien species.
- 1995 United Nations Fish Stocks Agreement (UNFSA) aims at long-term conservation and sustainable use of marine living resources. It calls on participating states to adopt an ecosystems approach, whereby dependent or associated species are taken into account; and to take measures to prevent or eliminate over-fishing and excess fishing capacity. It details, for the first time, the precautionary approach and how to apply it through the specification of precautionary reference points and the identification of management actions to be triggered in relation to these points.
- 1995 FAO Code of Conduct for Responsible Fisheries and the FAO Technical Guidelines for Responsible Fisheries (2003), together these intend to be holistic in nature and to cover all aspects of fisheries, including aquaculture, from initial exploration and planning through to post harvest practices.
- 1995 Kyoto Declaration on the Sustainable Contribution of Fisheries to Food Security emphasises the importance of fisheries as a food source for the world’s population. It sets out a number of principles that focus on sustainable development of fishery resources. The agreement contains actions to conduct integrated assessments of fisheries in order to evaluate opportunities, and strengthen the scientific basis for multi-species and ecosystem management.
- 2001 Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem addressed the issue of introducing more ecosystem considerations into conventional fisheries management. The Reykjavik Declaration calls for, *inter alia:* (i) introduction of management plans with incentives for sustainable use of ecosystems; (ii) strengthening of governance; (iii) prevention of adverse effects of non-fisheries activities on the marine ecosystems and fisheries; (iv) advances in the scientific basis for incorporating ecosystem considerations in management

(including the precautionary approach); and (v) monitoring of interactions between fisheries and aquaculture.

- 2002 World Summit on Sustainable Development and the Johannesburg Plan of Implementation (JPOI), encouraged the application by 2010 of the ecosystem approach, and the maintenance or restoration of stocks to levels that can produce the maximum sustainable yield, where possible but not later than 2015. To develop and facilitate the use of diverse approaches and tools, including the ecosystem approach, the elimination of destructive practices, and the establishment of marine protected areas (FAO, 2003 pp. 75-80; Cochrane and Doulman, 2005 pp. 78-80;; Edeson, 2005 pp. 17-20).

These instruments and agreements were developed in response to ocean and fisheries issues. Progress in adoption and implementation of these instruments, however varies at the regional and national level, and this is of concern at the international level. Some factors constraining implementation include the high levels of biological uncertainty; conflict between short-term economic and social objectives, and long-term sustainability objectives; poorly defined objectives in fisheries leading to ad hoc decisions, often based on immediate problems; and inadequate institutional capacity (Cochrane and Doulman, 2005).

The FAO monitors implementation of international instruments and reports biennially on progress towards implementation of the Code Conduct for Responsible Fishing; the four International Plans of Action (IPOAs); and the FAO Strategy for improving information on Status and Trends of Capture Fisheries. Evaluation by member countries, are submitted to the FAO Committee on Fisheries (COFI). A tool used for the preparation of this status report is the questionnaire sent to member countries (Caddy, 2007 pp. 1-6).

Pitcher et al. (2006) assessed how the FAO member countries were performing with regard to implementing the FAO Code. The evaluations of compliance requirements of Article 7 of the FAO Code by parties (53 countries representing 96% of annual world catch) were based on rapid appraisal of the biennial questionnaire. The evaluation of findings, report that progress of compliance with the Code, has been slow. With only 16 case studies noted by COFI in February 2003 and by 2007 only 37% (70 countries) of members had responded to the questionnaire. The information provided is a self assessment by members and this has led to some anomalies. For example 90% of respondents considered compliance with the code as good, but 25% stated that there were no fishery management plans (as required under article 7.3.3) at all in their jurisdiction (Pitcher et al., 2006 pp. 3-14).

Pitcher et al. (2009) evaluated the performance of 33 countries for implementation of EBFM based on three fields the EBFM principles, indicators, and implementation steps. Overall scores for the three fields resulted in only two countries Norway and USA (ratings over 70%) achieving a good performance; four had acceptable grades between 60% and 70% (Iceland, South Africa, Canada and New Zealand); with over half receiving fail grades of 40% or less. Another comparative assessment, in this case of biodiversity, fisheries and aquaculture in 53 countries (based on countries as selected by Pitcher et al. 2006) using a suite of fourteen indicators of resource management. Only four countries had an unweighted score of more than 5 out of 10 these were New Zealand (5.5), Peru (5.2), Germany (5.2), the Netherlands (5.1). These countries were considered to be incorporating best practices in their management of marine resources, but there was room for improvement. The USA, South Africa, and Australia had an unweighted score of 4.8 and these countries and the other remaining countries required improvement in their practices and policies in managing marine resources (Alder and Pauly, 2008 pp. 3-9) Given that Australia is often referred to as a world leader in fisheries management (McPhee, 2008) the results from this study placing Australia's performance in the acceptable category of grades is surprising. However, as Leadbitter and Ward (2007 pp. 459-460) highlight, assessment systems require a high degree of rigour and robustness for credibility particularly in terms of the purpose they were designed for, and the ability to demonstrate the effectiveness of the system being assessed.

2.5.2 Ecosystem Based Fishery Management

The concept

Marine ecosystems are perturbed by fishing and other human activities. Many fisheries are in decline and the effects of fishing on other ecosystem goods and services are beginning to be understood and recognised. Fishing can affect many species and disrupt important interdependent links within ecosystems, which may threaten marine biodiversity. Managing these impacts will require a much broader understanding of ecosystems and human systems than has been encompassed by traditional fishery management (FAO, 2009; Ecosystem Principles Advisory Panel, 1999). The intention for implementing EBFM is to improve fisheries management which considers the target fisheries stocks, and ecosystems that support fisheries (Garcia et al., 2003).

Traditional fisheries management has been concerned mainly with conserving parts of the system such as target fish stocks. Under this system consideration of the interlinkages between target, non-target species, habitats, biodiversity, and functional relationships, have generally not been an explicit objective. This approach has not always been successful in maintaining sustainability. EBFM requires the factors influencing important ecosystems processes, inter-relationships, and ecosystem attributes to be considered and taken into account. EBFM provides a more holistic approach, and is considered more likely to be successful in achieving sustainability of marine ecosystems and fishery resources (Botsford et al., 1997; Murawski, 2000). There is a large literature relating to EBFM approaches, therefore the number of EBFM approaches reviewed for discussion, have been limted to the following:

- Food and Agricultural Organisation of the United Nations (2003) *Fisheries management: the ecosystem approach to fisheries FAO Technical Guidelines for responsible fisheries* The FAO is the lead agency for fisheries at the international level and these guidelines have been produced to supplement the *FAO Code of Conduct for Responsible Fisheries* (FAO, 1995). The Code provides an operational reference for fisheries management, and it also contains a number of provisions for the development of an ecosystem approach to fisheries.

- Ecosystem Principles Advisory Panel (1999) *Ecosystem Based Fishery Management*: *a report to Congress by the Ecosystem Principles Advisory Board,* was an assessment of the extent to which ecosystem principles were being used in fisheries management and research. Together with recommendations for how these principles could be further implemented in the management of United States living marine resources, with the goal of maintaining ecosystem health and sustainability.

- Sissenwine and Mace (2003) *Governance for Responsible fisheries: an ecosystem approach,* is based on a review of the literature regarding sustainability and an ecosystems-based approach and the experience of EBM at the interface of science, fisheries management, politics and public opinion.
- Ward et al. (June 2002) report *Policy Proposals and Operational Guidance for Ecosystem-Based Management of Marine Capture Fisheries* builds on the FAO Code of Conduct for Responsible Fisheries, and the 1998 WWF/IUCN International Marine Policy, Creating a Sea Change. The report was prepared to encourage and inform global debate and provide an operational interpretation of how to apply the principles of ecosystem-based management to marine capture fisheries.
- Pikitch et al. (2004) view EBFM as a new direction for fishery management, essentially reversing the order of management priorities so that management starts with the ecosystem rather than a target species, and aims to sustain healthy marine ecosystems and the fisheries they support.

Overarching goals, objectives and principles

Many of the international fisheries instruments refer to the ecosystem approach and there are numerous definitions and interpretations of the EBFM approach (Morishita, 2008). According to Pitkich et al. (2004) EBFM takes a new direction for fishery management. The overall objective of EBFM is to sustain healthy marine ecosystems and the fisheries they support. To achieve this objective EBFM aims to avoid degradation of ecosystems as measured by indicators of environmental quality and system status; minimise the risk of irreversible changes to natural species assemblages and ecosystem processes; maintain long-term socio-economic benefits without compromising ecosystems; generate knowledge of ecosystem processes sufficient to understand the likely consequences of human actions; and where knowledge and understanding is limited, robust and precautionary fishery management measures should be applied.

The EBFM approach reflects the goals of both ecosystem-based management and fisheries management. The purpose of the approach is to plan, develop and manage fisheries in a manner that addresses the multiple needs and desires of societies, without jeopardising the options for future generations to benefit from the full range of goods and services provided by marine ecosystems. The FAO (2003) definiens EBFM as “an ecosystems approach to fisheries strives to balance diverse societal objectives, by taking into account the knowledge and uncertainties about biotic, abiotic, and human components of ecosystems, and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries”. Ecosystem management is described as, conserving the structure, diversity and functioning of ecosystems through management actions that focus on the biophysical components of ecosystems. The aim of fisheries management is to meet the societal and human goals of food and economic benefits through management of fishing activities (FAO, 2003 p. 6). EBFM is based on some important precepts as follows: the elimination of over-capacity and over-fishing; the rebuilding of depleted stocks; the protection of associated and dependent species; the conservation and maintenance of ecosystems, habitats, functional relations and productivity; applying the precautionary approach; and broadening stakeholder participation (FAO, 2003 pp. 83-87).

EBFM is a governance and management approach for responsible fisheries, and can complement and improve existing fisheries management, when dealing with oceans and fisheries issues (Ecosystem Principles Advisory Panel, 1999; Sissenwine and Mace, 2003). Addressing fisheries problems within an EBFM context requires governance systems that provide incentives to consider the health and sustainability of ecosystems as a primary goal. Managing human interactions within marine ecosystems requires an understanding of ecosystem characteristics and an ability to manage human activities that impact marine ecosystems (Ecosystem Principles Advisory Panel, 1999). Governance for responsible fisheries can be interpreted in many ways, and the terms used are often ambiguous. For an ecosystem approach to be responsible means sustainable production of human benefits, which are distributed fairly, without causing unacceptable change in marine ecosystems (Sissenwine and Mace, 2003).

EBFM has been an evolving process in response to two properties of natural systems, first, the effect of the natural environment on the resources being exploited; and second, the effect of resource exploitation on the environment. Both these are important and the management system should address both types of environment and ecosystem interactions. The primary goal of EBFM is recognising the critical interdependence between human well-being and ecological health (Ward et al., 2002 p.7). The principles of EBFM include recognising that ecosystems are dynamic, and the focus of management is maintaining the natural structure and function of ecosystems. Human uses and values of ecosystems are central to establishing objectives for use and management of natural resources. Therefore natural resources are best managed within a system that is based on a shared vision and set of objectives, developed amongst stakeholders; and management which is adaptive, informed by relevant knowledge, and continual learning (Ward et al., 2002 p. 10).

2.5.3 EBFM: key aspects and elements

Each approach to EBFM highlights similar themes and components, but tend to separate and group them differently. It is however possible to identify key aspects that underpin EBFM and the key elements considered necessary for its implementation. The key aspects that underpin EBFM are:

- clarification and understanding that our capabilities are limited to the governance and management of human activities not marine ecosystems;
- the importance of acknowledging societal choice and values as these are important factors in decision-making, and can affect governance and management outcomes;
- sustainability and resilience considerations are important to both marine ecosystems and human systems;
- the issue of centralisation and decentralisation as it relates to management roles and responsibilities, requires an awareness of placing local issues and interests within a larger framework of decision-making, as decisions need to be made at a number of different jurisdictional levels; and
- recognising that our understanding of marine ecosystems and human systems, and the interactions between them is limited, therefore under these conditions of uncertainty, it is prudent to apply the precautionary approach (FAO, 2003; Ecosystem Principles Advisory Panel, 1999; Sissenwine and Mace, 2003; Ward et al., 2002; Pikitch et al., 2004).

The key elements considered necessary for effective implementation of EBFM include:

- stakeholder participation in governance and management arrangements at all jurisdictional levels;
- clearly defined goals and objectives, the development of performance indicators and reference points, and includes monitoring and regular reporting;
- the allocation of effective user rights is viewed as a fundamental requirement as they outline a system of rights, rules and responsibilities that guide and control the human use of the marine environment;
- given the ecosystem and human systems uncertainties and lack of understanding, adaptive management has been proposed as a way of learning by doing, and then incorporating this new knowledge into decision-making;
- EBFM will require a wider range of both qualitative and quantitative information to be incorporated into any decision-making processes, and this will require a multi-disciplinary approach; and
- EBFM is an ongoing and evolving approach to resource management, and there are already effective procedures and processes in place that support the EBFM approach. Some changes will take time therefore an incremental approach to implementation has been advocated (FAO, 2003; Ecosystem Principles Advisory Panel, 1999; Sissenwine and Mace, 2003; Ward et al., 2002).

The question of what is to be managed – people or ecosystems, and the consideration of societal choice, values and decision-making are discussed below. Other key aspects and elements will be discussed in subsequent Chapters of Part One of the thesis.

Management of people or ecosystems

There often seems to be confusion over what is to be managed – ecosystems or the actions and activities of human systems that may impact ecosystems. This is a key point in terms of management as a technical activity, or as a practice of managing. Although scientific understanding of the ecosystems and fisheries has improved, we cannot manage ecosystems, but we can manage human activities that impact on ecosystems (Swissenwine and Mace, 2003; Rice, 2008). Mangel et al. (1996) distinguished between an ecosystem-based management approach, which implies management of, for example a target species that takes the ecosystem into account; and a comprehensive ecosystem approach that would require consideration of the target species, the effects of management on other species, and the ecosystem itself. Ward et al. (2002) suggested EBFM may be described as management of the use and values of ecosystems in conjunction with stakeholders, to ensure ecological integrity is maintained, recognising that ecosystems are dynamic and inherently uncertain. Often this is interpreted incorrectly as implying the management of ecosystems, instead of a more correct interpretation being the management of human activities that may affect ecosystems, often detrimentally.

Societal choice, values and decision-making

Different sectors of society view ecosystems in terms of their own economic, cultural and societal needs, and therefore, societal choice needs to be clearly articulated (Mangel et al.,1996). Societal choice and decision-making is thus a fundamental issue to be considered when implementing EBFM, as stakeholder choices influence how society values marine ecosystems, as well as decision outcomes (Keating, 2000). According to Charles (2001) analysis of fishery systems highlights the varied perspectives and multiple objectives of stakeholders and decision makers. It should also be noted, these decision makers have to operate in a complex environment, and that EBFM poses new challenges for governance and management.

Culture and values influence decision-making processes and outcomes. Values are used to evaluate decision alternatives, and may determine which problems appear on decision makers' agendas (Tonn, 2003). Therefore, any successful system of governance requires an understanding of society and its values as they play a major role in decision-making. People and groups hold different sets of values and may therefore view the same problem and the proposed solution very differently. Failure to take into account the various stakeholder values, views, understanding of the preferred outcomes, and incorporating these into decision-making can lead to conflict, which may result in inappropriate decisions for the environment and society (Harding, 1998). Human values play a dominant role in ecosystem management goals (Grumbine, 1994); and where human activities may be the cause of sustainability challenges, humans also have an integral role in achieving sustainability goals (Christensen et al., 1996).

Sustainable development and EBFM pose new challenges to the ways in which we define problems, identify solutions and implement actions. In many ways this can be linked to how people characterise the current situation and what constitutes a desirable future, and how that might be achieved. Such visions and outcomes are subject to differing world views and values, and may be dependent on particular drivers, or on political will to implement the necessary changes (Gallopin, 2002). It is often assumed that the western (developed world) approach is a universal epistemology, but in fact there are multiple epistemologies, ethical positions with respect to the environment, cultural traditions and perceptions towards managing ecosystems and resources, and cultural world views and values (Folke et al., 2000). Resource management outcomes are based on and are shaped by a range of different decision-making arrangements such as property rights regimes, incentive structures, cultural factors, and institutions. Attitudes towards nature are often reflected in the way societies are organised to use their resources (Westley, 2002). Unsustainable practices may relate to the different world views that people have of nature, and these assumptions may then affect policies and actions (Holling et al., 2002).

Political considerations are important as ecosystems and natural resource use may be subject to multiple political jurisdictions, and diverse political processes. It is also necessary to understand the use of political power by all actors, and the different discourses and opinions on what institutional approaches and methods are necessary to solve environmental problems (Pritchard and Sanderson, 2002). Resource managers, decision makers and the general public often voice their frustration at not hearing clear and consistent answers to key questions concerning environmental and renewable resource issues. There may however, be no simple answers as the problems and issues are complex, and understanding the interactions between natural and human systems is not yet well developed (Westley, 2002). Fisheries management has often focused on a limited set of goals and objectives. Whereas an EBFM approach recognises a wider range of choices and options towards oceans and fisheries resource management, by taking into account the benefits of both conservation and use of these resources. These include the often overlooked value of ecosystem goods and services and the full range of potential benefits they provide toward environmental and human well being (FAO, 2003).

2.5.4 Challenges in implementing EBFM

There will be challenges in implementing EBFM in terms of the complexity of ecosystems and ecological uncertainties; conflicts of interest between the competing users; conflicting stakeholder objectives; and an increase in the number of participating stakeholders (Sutinen and Soboil, 2003). The FAO (2003) also identified a number of impediments relating to the implementation of EBFM, and some of these were:

- A mismatch between expectations and resources, both human and financial. The differing timetables of the political and the management process may also mean that insufficient commitment and resources are made available. EBFM is a long-term commitment with long-term benefits, these may be difficult to present convincingly to governments, which normally work within shorter cycles, and especially when long-term EBFM objectives compete with short-term socio-economic objectives.
- Difficulties may be foreseen in reconciling competing objectives of the multiple stakeholders. In some, perhaps many cases, the participatory process may be insufficient for finding compromises that satisfy all stakeholders. Conflicts may then require higher-level intervention to determine the relative priorities and possibly, compensation.
- The time and cost required for effective consultation with a wide range of stakeholders could be substantial.
- Insufficient knowledge will continue to be a constraint. Biological uncertainty is recognised as a substantial problem in management and the combined biological and ecological uncertainty under EBFM will be even greater. A further source of uncertainty is a widespread lack of adequate knowledge of fleet and fisher behaviour and dynamics.
- A lack of adequate capacity for informative compilation and analysis of the available information will often add to the uncertainty. In cases where there have been inadequate monitoring and data storage systems in place, the problems will be particularly acute.

- Issues will be difficult to resolve in relation to responsibility for ecosystem degradation, between ocean and fisheries and other economic activities and sectors.
- Poverty is a major threat to EBFM where poor coastal dwellers have few options to derive livelihoods. Fishing will continue to be the occupation of last resort, resulting in excessive fishing effort, depletion of resources and ecosystem degradation. This will often occur in circumstances where the incentive to care for the ecosystem is overshadowed by daily necessities (FAO, 2003 pp. 69-71).

2.6 Current fisheries debates and issues

There has been increasing debate regarding the current status of fisheries and fisheries futures, and the underlying causes. There are also a range of fisheries issues and challenges for fisheries management, which are also important for the successful implementation of EBFM.

2.6.1 Fisheries status, futures, and management options

A series of high profile papers in *Science* and *Nature* (Worm et al., 2006; Pauly et al., 1998; Pauly et al., 2002), suggest that most fisheries world-wide are over-exploited with predictions for their collapse; that current fisheries management has failed; and that new solutions are required. Although fisheries governance is often implicated, evaluations of solutions are rare (Hilborn, 2007a). As Hilborn (2007b) argues these views are not helpful and that the status of fisheries and fisheries management can be reinterpreted differently, as there are alternative interpretations of the data. Despite the competing views on the state of fisheries and ecosystems, and the appropriate governance arrangements to be applied, there is general support for lower fishing pressure, higher fish abundance and less impacted ecosystems. The challenge is to determine which tools will best achieve such outcomes.

Worm et al. (2006) argued in 2003, that 29% of the world’s fish stocks were collapsed and projected that by 2048, 100% of all major fisheries stocks would be collapsed. The proposed solution was a network of Marine Protected Areas (MPAs) and areas permanently closed to fishing. In response Hilborn (2007b) argues that the effectiveness of fisheries management world-wide differs considerably, and the situation is not as dire as Worm and others suggest. Hilborn (2007b) cites examples in the USA where the proportion of over-fished stocks has declined from 33% in 2001 to 26% in 2005; world-wide the proportion of major fish stocks that are over-fished has been stable in the range of 20-30% since 1990; and the Marine Stewardship Council has certified a number of fisheries as sustainably managed. This alternative interpretation demonstrates that methods to achieve sustainable fisheries are available and have been applied (Hilborn, 2007b pp. 1362-1364).

Pauly et al. (1998; 2002) reported that the mean trophic level of fish in most of the world's major marine ecosystems has declined and this indicates a "fishing down of the food chain." That management has not sustained target stocks, and propose MPAs as a solution. Essington et al. (2006) describe two ways in which fishing down the food chain can occur. First, through the sequential replacement of, high value upper trophic level species, with less valuable, lower trophic level species. Second, the sequential addition of lower trophic fisheries within an ecosystem referred to as fishing through the food web, where fisheries for high trophic level species are maintained despite a decline in the overall mean trophic level of landings. Although Hilborn (2007b) acknowledged most large fish of target species have been reduced in abundance due to fishing, and in some places larger fish have been over-fished, there are however, in many major fisheries, where large fish species remain at or above levels that produce optimal yields. Hilborn (2007b) argues single species management, when fully implemented works well for target stocks, if stocks are maintained at levels that produce maximum sustainable yield (MSY), and that EBFM has an important role in avoiding bycatch of non-target species (Hilborn, 2007b pp. 1364-1366).

Watling and Norse (1998) argued bottom trawling was analogous to forest clear cutting and that the area of the ocean cleared each year was equivalent to the entire Amazonian rain forest. The policy implication is bottom-contact fishing gear should be banned with a move to pots, hook and line methods that have less impacts on benthic ecosystems. Hilborn acknowledged bottom trawling does reduce the diversity of some kinds of habitat, such as corals, but argues that for other habitats, such as mud and sand bottoms, impacts on these ecosystems are much less. He notes that the trawled areas have usually been trawled previously, in some areas several times a year, and for others over many decades. Hilborn (2007b) argues the debate on the effects of trawling, should consider whether the practice modifies productivity of marine ecosystems for the target species, but this question has not been addressed in the literature. The policy implication is that ocean zoning should be introduced, restricting trawling to permitted areas. Some non-government organisations agree with this view, and increasingly areas of the ocean are being declared trawl-free zones. Hilborn agrees that this approach would be prudent for highly sensitive habitats (Hilborn, 2007b pp. 1366-1367).

As discussed by Alverson (2002) there have been debates between academics, governance and management institutions, stakeholders, and the broader public regarding the underlying causes for the current status of fisheries world-wide. These include poor policy and management decisions in dealing with the issues of over-fishing, over-capacity and subsidies (as outlined below) and socio-economic and political factors. As well as issues regarding scientific uncertainty, as well as an unwillingness to accept scientific findings, or act on scientific advice. According to Allio et al. (2006) during the last two decades new ideas, values, beliefs and moral dichotomies have also emerged regarding the best way to protect the planet from risks, with some authors considering these concerns as a social and ethical issue, not just a scientific one.

Link (2005) suggests the broader conceptual context of EBFM debates and discussions are moving from the definition stage towards implementation, and the major disagreements over possible solutions are more related to how it is to be achieved. Some authors advocate a strong top down centralised government control approach, whereas others argue for an incentives based and participatory approach. Mace (2004) highlights four major problem areas that need to be addressed to ensure robust and productive marine fisheries now and for the future. These are regarding fishing mortality rates; over-capacity; lack of adequate basic data; and lack of adequate governance systems. Mace (2004) also argues, the claims made that traditional fisheries management has failed, but notes in practice however there have been very few examples where management measures have been fully implemented. Although there are diverging views on the status and future management of the world’s fisheries, along with some failed fisheries there are also examples of successful fisheries (Hilborn, 2007a). As Parma et al. (2006 p. 413) state “Now that failures have received due attention, the time has come to scrutinise achievement around the world and derive the appropriate lessons”. At the fifth William R. and Leonore Mote International Symposia (9-11

November 2004, Sarasota, Florida), John Annala summarised seven principles for successful fisheries management. These were the establishment of appropriate institutional frameworks; define clear management objectives; clarify and specify rights; create and apply incentives; develop open and transparent management systems; internalise externalities; and fill the fisheries management toolbox (Parma et al., 2006, p. 415).

More recently as Worm et al. (2009) discuss current trends and future prospects for fisheries and the proposed solutions remain controversial. Although sustainability goals have been set, progress has been slow, as there has been an unwillingness to bear the short-term social and economic costs of reducing fishing, but the adoption of an ecosystem approach may influence fisheries management outcomes. In response to these debates and diverging perspectives, and to provide an integrated assessment of the status, trends and solution in marine fisheries, well studied ecosystems were analysed from a fisheries and conservation perspective. Outcomes from this analysis concluded that currently marine ecosystems are subjected to a range of exploitation rates resulting in a mosaic of stable, declining, collapsed, and rebuilding fish stocks and ecosystems. As discussed (Mace, 2004; Hilborn, 2007a; Hilborn, 2007b; Hilborn, 2007c), there are examples where management actions have been successful in controlling exploitation and that marine ecosystems can recover if exploitation rates are reduced. There are still areas, including those outside national jurisdictions where effective management is lacking. Although the best use of management tools may depend upon the local context, it is likely that a combination of traditional approaches (catch quotas, community management), coupled with other strategic measures (fishing closures, selective fishing gear, ocean zoning) will provide the potential for restoring marine fisheries and ecosystems and minimising against further over-exploitation.

2.6.2 Fisheries issues

There is general agreement that the major issues for fisheries, such as over-fishing and over-capacity, but as discussed above, there is disagreement as to the solutions. The issue of capacity and the related issue of subsidies are seen as a critical obstacle in achieving EBFM for fisheries (Ward et al., 2002). Another issue is that of illegal, unreported and unregulated (IUU) fishing. In response the FAO have developed an

International Plan of Action (IPOA) for the Management of Fishing Capacity (FAO, 1999c) which encourages states to address the problem, through capacity management in order to align fishing capacity with the sustainable use of fish stocks. A number of FAO Technical Fisheries Papers and guidelines have been published to aid stakeholders and fisheries mangers in developing National Plans of Action (NPOAs) for the management of fishing capacity (FAO, 2008 p.iv). The FAO has also developed an International Plan of Action (IPOA) to prevent, deter and eliminate Illegal, Unreported and Unregulated Fishing (FAO, 2001). The FAO also published a set of Technical Guidelines to aid the development and implementation of National Plans of Action (NPOAs) for Illegal, Unreported and Unregulated Fishing (FAO, 2002). Other important statements of intent developed by the FAO include an IPOA for seabirds (FAO, 1999a), which is a voluntary instrument that applies to all states (nations) whose fishermen engage in longline fisheries, to reduce the incidental catch of seabirds in longline fisheries. The IPOA for sharks (FAO, 1999b) is a voluntary instrument that applies to all states (nations) whose fishermen engage in shark fisheries, for the conservation and management of sharks.

Over-fishing

Over-fishing is a common problem, as the world's oceans are at or near maximum sustainable yields, and rebuilding depleted fishery resources is a world-wide problem (Brodziak et al., 2008). To understand the issue of over-fishing it is useful to review the history and development of fisheries from a global perspective. The period after World War Two was one of intense fisheries development, where world fisheries production increased, and major problems affecting fisheries in the northern hemisphere were identified in 1945 (Hall, 1999). Between 1959 and 1972 there was a rapid geographic expansion of fisheries, and the world catch rate doubled from 30 to 60 million tonnes. During this period severe over-fishing occurred in many developing counties; and was accompanied by public concern for the mismanagement of fisheries. Between 1972 and 1982 fisheries production increased from 60 to 68 million tonnes and the status of fish stocks deteriorated. Between 1983 and 1992 catches increased from 68 to 85 million tonnes and global issues of sustainability and the environmental implication of fisheries were raised (Hall, 1999 pp. 3-5). The continuing problems of over-exploitation of fisheries resources led to the 1992 International Conference on Responsible Fishing, which formulated a declaration and a series of principles, and was subsequently followed by a more complete specification within the 1995 FAO Code of Conduct for Responsible Fishing.

The FAO provides biennial reports on the state of world fisheries and aquaculture. The current *State of world fisheries and aquaculture 2008*, notes with regard to the overall state of fishery resources, that the proportion of over-exploited, depleted and recovering stocks has remained stable over the last ten to fifteen years, after the noticeable increasing trends observed in the 1970s and 1980s with the expansion of fishing effort. Global estimates of fish stocks for 2007 were as follows: moderately exploited (20%); fully exploited (52%) over-exploited (19%); depleted (8%); and recovering (1%). Most of the top ten species (30% of total world capture) are fully exploited or over-exploited. These statistics suggest that the maximum wild capture fishery potential has probably been reached, and reinforces the call for more cautious and effective fisheries management, particularly for some highly migratory and straddling species, and other fishery resources exploited in the high seas (FAO, 2009 pp. 7-8).

The world’s oceans and fisheries have been changed and impacted throughout human history so it is difficult to predict what ecosystems would look like in the absence of fishing. As Pitcher (2005) outlined the “back to the future” approach includes methods for describing past ecosystems, designing fisheries that meet criteria for sustainability, and evaluating the costs and benefits of fisheries in restored ecosystems. According to Ward et al. (2002) preventing further decline is an imperative, because setting ecosystem targets and benchmarks can be influenced by shifting baselines, where successive generations have lower expectations of what are acceptable ecosystem changes. Marine ecosystems are not well understood and there are few long-term datasets, under these conditions it is difficult to predict and recognise ecosystem changes due to natural variability or those due to human impacts, especially in relation to shifting baselines (Ward et al., 2002 p. 9). The purpose of traditional fisheries management was to ensure that harvesting of fish stocks were ecologically sustainable in the long-term (King, 2007). In the past new fisheries have often been fully capitalised and reached unsustainable catch rates before management processes and measures have been established as effective constraints (Kaiser et al., 2005 pp. 416-418). Guidelines developed by FAO (2003) include avoiding over-fishing, and where stocks have been reduced to low levels that these should be rebuilt, noting that once threshold limits have been exceeded changes may be irreversible. The rebuilding of stocks by 2015 was also a requirement under the 2002 WSSD JPOI. As outlined by Brodziak (2008) when developing a rebuilding plan it is important that stakeholders understand the timeframe required for rebuilding depleted fishery resources.

Over-fishing may result in growth over-fishing, that is a level of fishing in which many small individuals are caught before they grow to a size where the stock biomass is maximised (a level of fishing greater than that required to maximise yield or value per recruit). More serious is recruitment over-fishing that is a level over-fishing in which spawning stock are reduced to the level where the relationship between stock and recruitment, and the number of recruits produced are insufficient to maintain the population (Beamish et al., 2006; King, 2007 pp. 374-376). As a consequence of over-fishing, many ecosystems exhibit ecological changes due to over-harvesting of fish stocks (King, 2007). Beamish et al. (2006) identified longevity over-fishing, the removal of large numbers of older age groups of long lived species are removed by fishing. Beamish et al. (2006) argue that if older age classes have greater resilience (due to life history strategies) to environmental perturbations than younger fish, this could prevent a population from rebuilding after periods of unsuitable ocean conditions. According to Murawski (2000) there is no consensus on criteria for defining ecosystem over-fishing. However, it is possible to identify the symptoms of ecosystem over-fishing, which include reductions in diversity; reduction in aggregate production of exploitable resources; decline in mean trophic level; increased bycatch; greater variability in abundance of species; greater anthropogenic habitat modification; and in extreme cases changes to alternative stable ecosystem regimes.

Over-capacity

Over-capacity is a key factor contributing to the decline of many of the world's fisheries (Mace, 1997). Excessive fishing capacity is often a result of over-capitalisation and is of increasing concern, as it affects sustainability, undermines conservation management responses, and is economically wasteful (Greboval and Munro, 1999). The issues of over-capacity in fishing fleets and their reduction to the levels that should be in balance with long-term sustainable exploitation of resources have received global attention in the past two decades (FAO, 2009 p. 29). The *State of World Fisheries and Aquaculture 2006* included information on over-capitalisation and excess capacity in world fisheries, but statistics on total tonnage and total power of world fishing are not available on a global basis. The issue of over-capacity in fishing fleets has been of concern for the last 20 years, with many countries introducing measures to deal with the issue (FAO, 2007). The FAO Code of Conduct for Responsible Fishing (FOA, 1995) outlined the need for states to take measures to prevent or eliminate excess fishing capacity. The code was followed by the 1999 FAO International Plan of Action for the Management of Fishing Capacity, to be implemented by 2005, through regional fisheries organisations and by states (FAO, 2007).

Over-capacity includes both over-capitalisation in terms of investment in vessels and equipment, and the numbers of fishery operators participating in a particular fishery. In some cases over-capacity has been caused by government intervention though subsidies. The capacity of fishing has been estimated to have increased fourfold since 1965, and is greater than the growth in landings. The need for effective management of fishing capacity has been recognised because many of the fishing resources are biologically and economically over-exploited. Fishing nations are experiencing the limits of sustainable exploitation and are increasingly recognising the need to deal with the issue through structural adjustment programs (jurisdictional, fiscal, political, biological and economic components) in terms of change in management procedures to achieve desired outcomes (Metzner and Rawlinson, 1998).

The elements for managing capacity are a means to assess current level of capacity, identify the desired level of capacity, and a mechanism to reach that level. Capacity may be expressed in terms of inputs (potential fishing effort) or outputs (potential catch). Capacity and capacity utilisation relate in the short-term to the ability of the existing fleet to increase output given current conditions. Over-capacity and over-capitalisation are longer-term concepts that indicate the extent to which the current fleet may need to be reduced, in order to meet a long-term target level of output. Fleet capacity has four components: the number of vessels; size of each vessel; technical efficiency of vessel operation; and potential fishing time of each vessel, per specified period of time (Pascoe et al., 2003). Evaluation of fleet capacity in relation to the increasing fishing power and the use of technology on fishing boats is important due to effort creep. The key is to plan the desired fishery configuration (number and types of fishing units) and limit the overall fishing effort at sea through effective management and capacity reduction (Ward et al., 2002). It may be difficult to interpret indicators of over-capacity, such as a decline in catch and reduced fishing seasons. Garcia and Newton (1997) suggested that a reduction of up to 50% in fishing capacity may be required for the sustainable harvest of many fisheries; and estimated world fishing capacity would need to be reduced by 25% for revenues to cover operating costs, and by 53% for revenues to cover total costs.

The issues of over-capacity are complex. It often reflects high investment and debt for fishers which may lead to increased harvesting that exceeds MSY in order to service the debt. Solutions to the problem are not simple for technical, political and social reasons. Governance and management need to take into consideration concerns regarding food security, the economic and financial impacts of adjustment on commercial fishers, fishing communities and the local economy. Even with a well defined property rights based system, these will still need to be monitored as imperfect markets may continue to provide incentives for over-capacity, together with technology developments, which increase fishing power and result in effort creep. Political pressure to increase yield from a fishery in some cases outweigh the biological advice to reduce harvest levels to rebuild stocks (Ward et al., 2004). Subsidies can result in over-capitalisation leading to over-capacity and over-fishing and have been significant in distant water fishing nations (DWFNs), and trans-boundary and high seas fishery resource issues (Greboval and Munro, 1999).

Government subsidies

While the threat of over-fishing has been well publicised government subsidies are also a major reason why fisheries are not sustainable. Subsidies result in over-capacity that leads to over-exploitation of fish resources. Basic economic theory argues that fisheries should be self sustaining, but fisheries receive government subsidies which enable otherwise unprofitable fleets to continue fishing. Subsidies also introduce trade distortions, as countries that do not provide subsidies are disadvantaged, as their counterpart in the subsidising countries can supply fish at a lower price and still make a profit (Sumaila et al., 2007). The need for action to reform fishing subsidies was identified at the 2002 WSSD in Johannesburg, and has been discussed by international intergovernmental bodies, and national governments. The *State of World Fisheries and Aquaculture Report 2006* (FAO, 2007) noted that subsides influence the economic, social and environmental dimensions of fisheries, involving many different stakeholder interests. Technical aspects have been discussed and working group activities have been undertaken by the Food and Agriculture Organization of the United Nations (FAO); United Nations Environment Programme; Asia-Pacific Economic Co-operation; and Organisation for Economic Co-operation and Development (OECD); and other international organisations. Policy issues form part of the agenda for the multi-lateral trade negotiations in the World Trade Organisation (WTO). Previously discussions focused on subsidies which contributed to over-capacity and over-fishing, but more recently have included subsidies that seem to be expanding into other areas, such as aquaculture and fish processing (FAO, 2007 pp. 60-61). Non-government organisations such as the International Centre for Trade and Sustainable Development (ICSTD) and the World Wide Fund for Nature (WWF) are also actively engaged on this issue (Gooday, 2002).

Subsidies to the world’s fishing fleets are significant and are high compared with subsidies for other food products, with 1990s estimates at US$14-20 billion a year compared with world fishing revenues of US$85-95 billion a year (Milazzo, 1998). More recent estimates puts global fishery subsidies at US$ 30-40 billion per year, and of this sum US$6-10 billion may go to bottom trawlers alone (Sumaila et al. 2007). Gooday (2002) discusses the related issue of over-capacity and unsustainable levels of fishing (over-fishing) together with government subsidies and the need to clarify and improve the situation regarding fisheries subsidies. The international debate relates to the consequences resulting from these subsidies and what actions are needed. The types of subsidies may include: direct transfers; lending support programs; fuel subsidies; tax preferences and insurance support programs; sector specific employment and social security provisions; general services; and marketing and price support programs (Gooday, 2002 pp. 2-3; Schrank, 2003 pp. 10-14).

The World Trade Organization (WTO) also has a role to play, as fishing subsidies distort international trade and markets. The WTO Committee on Trade and Environment began formal work in 1997, and the 2001 Doha Declaration commits members to clarify and improve the situation regarding fishing subsidies. There is currently no agreement or definition on what a subsidy is; how the effects can be measured; or when they are useful or harmful. There are difficulties with evaluating the effects of subsidies on the economy, environment, international and internal trade, and the sustainability of fish stocks. Many subsidies may have been useful at the time of introduction and justified in economic terms, but over time have became entrenched, often serving the interests of participants, and eliminating them can be a difficult political issue (Schrank, 2003; Schorr, 2004; FAO, 2004 pp. 128-131). If global fisheries are to attain sustainability, the elimination of fishing subsidies is necessary, as currently the global fishing fleet is twice the size that the oceans can sustainably support. Unilateral action by individual countries may not be attractive as such countries would suffer trade disadvantages, but multi-lateral actions could be effective with all nations ending or reducing subsidies under similar rules. The WTO is the only global multi-lateral organisation that can enforce its agreements. According to Sumaila et al. (2007) under the current Doha Trade Round Negotiations there is a possibility that member countries may agree to cut government subsidies to fisheries.

Illegal, unreported and unregulated (IUU) fishing

Illegal fishing refers to fishing carried out by unauthorised vessels; unreported fishing refers to fishing in which catches have not been reported to management authorities; and unregulated fishing refers to fishing activities carried out in the absence of management measures (King, 2007; Sumaila et al., 2006). Unregulated fishing is conducted by vessels without nationality, or flying flags of the state, which do not belong to relevant fishing organisations and therefore do not consider themselves bound by those organisations rules (Le Gallic, 2008). Although some international instruments contain provisions that relate to IUU none of these were set up directly to deal with the issue. IUU is commonly understood to refer to fishing activities that are inconsistent with or in contravention of the management or conservation measures in force for a particular fishery (Kirkwood and Agnew, 2004).

IUU, although not new, has recently become a major international issue. IUU has become a global widespread activity involving fishing companies and fishers from many countries and occurs in both national waters and on the high seas. The recent emergence of organised IUU fishing operations through fleets of vessels with common ownership has also facilitated and accelerated the development of IUU fishing (Sumaila et al., 2006; Le Gallic and Cox, 2006). An outcome and impact of IUU is that it can undermine regional and national state management strategies aimed at managing fisheries on a sustainable basis, or when rebuilding depleted stocks. It may also undermine mitigation measures developed, for example to reduce bycatch as unregulated fleets are unlikely to implement such measures (FAO, 2002).

Under the FAO IPOA IUU is defined as illegal fishing conducted by vessels of countries that are parties to Regional Fisheries Management Organisations (RFMOs) but operate in violation of its rules, or operate in a country’s waters without permission. The IPOA is a voluntary instrument that applies to regional bodies and states, entities, and to all fishers. The IPOA addresses the nature and scope of IUU; its objectives and principles and the implementation measures to prevent and deter IUU fishing. These measures focus on regional and state responsibilities; flag-ship responsibilities; coastal state measures; port state measures; and internationally agreed market related measures (FAO, 2001). The FAO also developed a set of technical guidelines for the implementation of the IPOA to prevent, deter and eliminate IUU. The guidelines review the available measures and provide advice for decision makers and policy makers associated with the management of fisheries and how the measures may be used and implemented (FAO, 2002). Following this initiative the 2002 WSSD called for the control of IUU by 2004. At the June, 2003 G8 meeting in Evian, Heads of State adopted a G8 Action Plan for the elimination of IUU fishing. More recently the Organisation for the Economic Co-operation and Development (OECD) Committee for Fisheries completed a major study to address the full economic dimensions of IUU fishing, in an integrated and comprehensive manner to make sure that all the underlying causes had been correctly identified in order to select the most appropriate solutions (Sumaila et al., 2006; Le Gallic, 2004; Le Gallic and Cox, 2006).

IUU involves the illegal harvesting of fish, shipment, processing, landing, sale and distribution of fish and fishery products, as well as support and provisioning of vessels. Because it is unreported it is difficult to quantify (FAO, 2007). However information available suggests it may account for up to 30% of total catches and that the amount world-wide is increasing. Examples of IUU catches for the 2000/01 period for particular areas and fisheries are as follows: in the Antarctic area 39% of the total Conservation of Antarctic Marine Living Resources (CCAMLR) catches; within the International Commission for the Conservation of Atlantic Tunas (ICCAT) 18% of all fishing activity for tuna; 20% of redfish traded internationally entered the market through IUU vessels; within the North West Atlantic Fisheries Organisation (NAFO) 10,000 tonnes of groundfish (plaice, cod and redfish) were illegally caught; and in Greenland halibut quotas were estimated to have been exceeded by 2,100 tonnes (10% of total allowable catch) due to IUU activities (Le Gallic, 2008).

In order to develop measures that deter IUU it is important to understand the incentives for IUU. According to Le Gallic and Cox (2006) over-capacity, ineffective management and subsidies are identified as three of the major economic causes for IUU. Gaps in the current international regulations also allow some IUU activities to be practised beyond the reach of national and international regulations. Particularly, those who register and flag vessels in a foreign state, with the purpose of circumventing regulations; and those foreign states that utilise or facilitate use of Flags of Convenience. Kirkwood and Agnew (2004) argued that generally vessel owners would prefer to fish legally and IUU is often undertaken for economic reasons. The incentives may be due to measures such as reductions in allowable catch aimed at managing the fisheries on a sustainable basis, which may then lead to displacement of fishing effort into IUU options. Incentives include profits from the sale of high value catches such as tuna, the Patagonian toothfish, or abalone which may occur through unrestricted markets, as well as illegal trading in over quota catches taken in regulated fisheries (called black market fish). The operational costs of IUU fishing can be less than for those of legal fishing vessels as they do not pay management costs; fishing practices are not subject to the same regulations; and operational costs (wages and health and safety conditions) are lower. Surveillance and interception of illegal vessels is costly and is difficult in remote locations, and the penalties may not be considered high if caught. As outlined by Le Gallic and Cox (2006) social factors such as poor economic conditions and prospects in some developing counties provide a pool of available and cheap labour, which may force crews to accept work on flags of convenience vessels. For example, during the 1990s, in Australia the poaching of trochus was undertaken by Indonesian fishermen driven by extreme poverty.

Outcomes from an OECD study concluded that current conditions make IUU profitable and identified actions and measures needed to make it unprofitable, by reducing revenues from IUU fishing; increasing operating costs for IUU activities; increasing capital costs of IUU vessels; and increasing the cost of risk of engaging in IUU activities. As well as improving the effectiveness of the current legal framework and monitoring control and surveillance (MCS) activities (Le Gallic and Cox, 2006). The more recent use of trade measures relate to import restrictions; catch document schemes and labelling; and restricting the provision of goods and services to vessels while in port. On the basis, countries affected by the use of these trade measures, for participating in IUU activities, will change their behaviour; and that improved enforcement methods will reduce incentives for IUU activities. These measures however, have to be consistent with WTO rules. Although it is difficult to measure effectiveness of trade measures there is a growing interest by policy makers for this type of action and it may be one of the few options for the fishing community to act against IUU activities. Unilateral initiatives might play a role in the short-term, but multi-lateral international actions are needed to modify the incentives in the long-term (Le Gallic, 2008).

2.7 A systems approach

Under EBFM principles ecosystems and human systems are viewed as part of one system, with the focus on understanding the dynamic interactions within and between them ecosystems and human systems (see Chapter 1). Generally ecosystems and human systems have been examined separately however, a number of authors (Charles, 2001; Folke et al., 2000; Westley et al., 2002; Garcia and Charles, 2007; Fulton et al., 2007) propose a systems approach for understanding and linking ecosystems and human systems. A systems approach provides a conceptual framework for thinking about phenomena, to order material, and reveal patterns (Berkes and Folke 2000; 2002). Ecosystems and human system and their respective components have long histories of discipline based theories, and methods, and one way to understand how these components interact is to link them within a common framework (Westley et al., 2002). More recently the study and management of social-ecological systems (SESs) has been used to help integrate these theories; developing conceptual frameworks to provide a better understanding of the dynamic interactions operating at multiple scales between human systems and ecosystems. Also drawing on complex systems theory, to identify how human societies deal with change in linked social and ecological systems, and develop resilience and adaptive capacities, that do not foreclose on future options (Walker et al., 2006; Anderies et al., 2006). This highlights the need for a comprehensive approach to fisheries sustainability, together with a simple representation of the complexity, which is a challenge (Garcia, 2005 p. 187). According to Garcia and Charles (2008) fisheries systems represent a network of interlinked subsystems.

EBFM is complex, and a systems approach is one way to both embrace the complexity and simplify it. Although there is a considerable literature on EBFM it lacks a clear definition; it includes many concepts, aspects and elements but does not articulate how these are linked; with much less on implementation; and no general agreed framework for description and assessment. A systems approach is a useful way to deal with these difficulties. It potentially provides order; the ability to ask the right questions and to evaluate performance; and improve design by assessing the governance and management strategies in the context of the overall oceans and fisheries system. A systems approach will also aid decision makers and other stakeholders, who have an interest in, and a role and responsibility for oceans and fisheries management. It will also support the implementation and assessment of EBFM. To assess management strategies in the context of the overall fisheries system that links the marine ecosystem, users, scientists, government agencies and other stakeholders, it is helpful to begin to get a sense of what such a system might look like. An integrated systems model under EBFM principles, has been developed, and is presented in Figure 2.7.

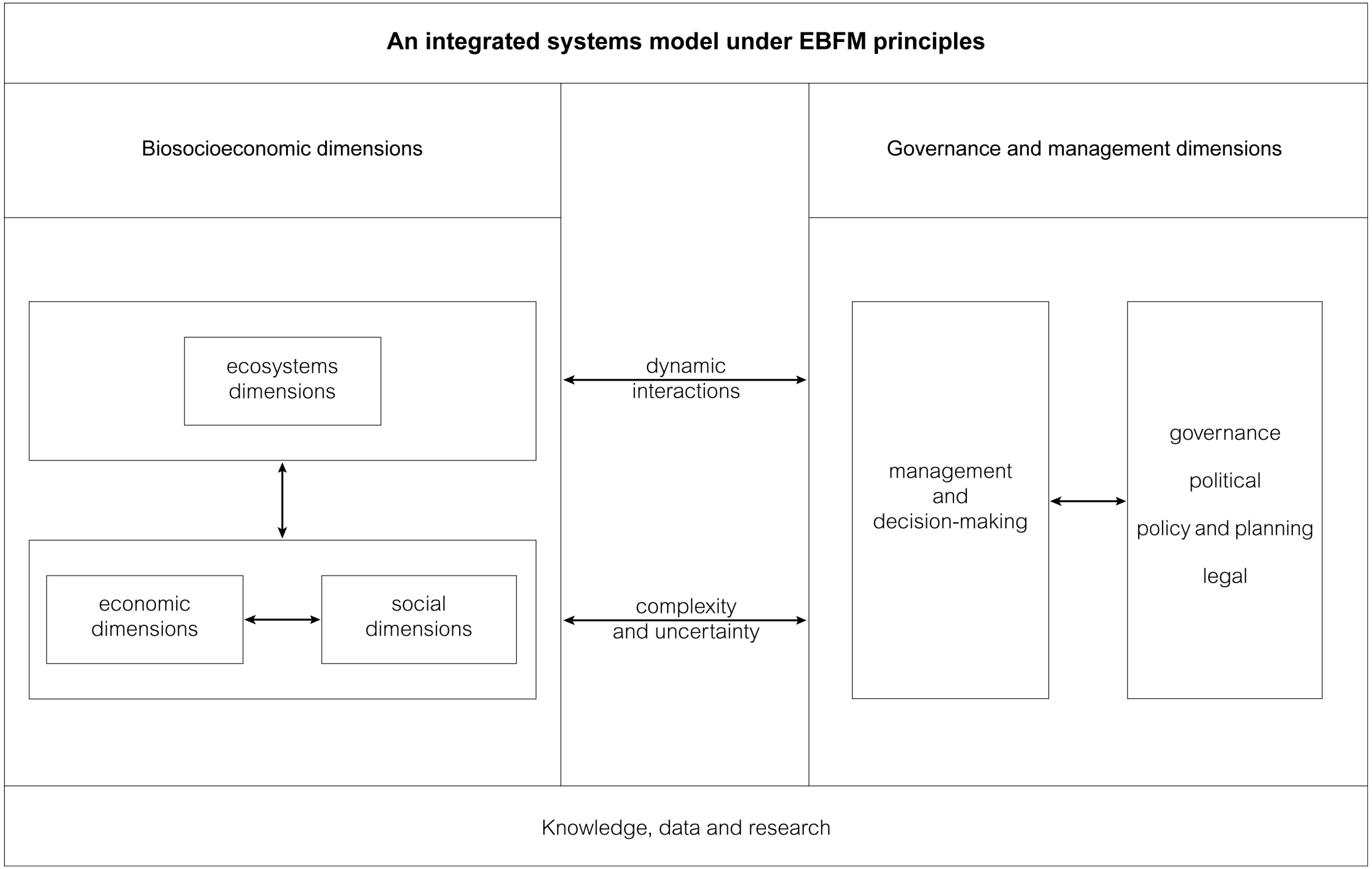


Figure 2.7: An integrated systems model under EBFM principles.

The key features of EBFM are the consideration of the ecosystem, economic and social dimensions in an integrated manner; improving governance and fisheries management response to biosocioeconomic issues; and making informed choices on appropriate solutions and actions, based on an understanding of the whole system. The above model identifies the biosocioeconomic, governance, and management dimensions and subsystems. Ecosystems provide goods and services that humans and other species rely upon for wellbeing and survival, and these may be impacted by human activities. The cumulative effects of human activities may pose a threat to the terrestrial and marine ecosystems, which if not correctly managed may result in changes to the supply of vital ecosystem goods and services, or ecosystems may undergo regime shifts that can affect economic and social conditions and opportunities. The difficulty is in understanding the individual ecosystem, economic and social dimensions (termed here as biosocioeconomic), and the dynamic interactions within and between them, and how in turn these respond to governance and management intervention. To be effective governance and management responses need to be comprehensive and coherent; and co-ordinated within and across institutions and jurisdictions. Knowledge, data and research underpins all aspects of governance, management and stakeholder decision-making. In many cases, however the knowledge and science may be limited. Under these circumstances complexity and uncertainty is a major feature of ecosystems and human systems.

Despite these difficulties and challenges the adoption of a systems approach together with the development of the integrated systems model will be of great benefit in being able to view the system as a whole, as a means of unpacking the system, and identifying the subsystems. It also makes possible a systematic review of the implementation of EBFM from different perspectives within the system (biosocioeconomic, governance, and management), and at a range of jurisdictional levels from the local, to national and regional. The model highlights the interconnected nature of the biosocioeconomic dimensions and the consequential complexity and uncertainty for governance and management. Interactions within and between the governance and management dimensions are also complex.

The dynamic relationships, interconnections, and key interdependencies and interlinkages within the integrated model will be further discussed and developed in subsequent Chapters. The model will be used to help unpack these dimensions in a systematic manner in order to develop a theoretical and conceptual understanding in Part One of the thesis, and to then apply the model empirically in Part Two of the thesis.

2.8 Summary

The emergence of sustainable development and EBFM has been in response to a growing awareness of the outcomes of unsustainable resource exploitation on marine ecosystems. Traditional oceans and fisheries management approaches tended to view ecosystems as fixed and closed systems, and the focus was often on a single fish stock, (although some tried to deal with multi-species fisheries), and defining sustainable yields. A fundamental shift in thinking has occurred with regard to oceans and fisheries governance and management. Oceans ecosystems are recognised as being dynamic and open systems, and once threshold limits are reached or exceeded, shifts into different stable states may occur, and these changes may be irreversible. Marine ecosystems are subject to natural variability that affects productivity, and in turn dictates the abundance and natural mortality of fish stocks. Fisheries are complex coupled human-in-nature systems, and an EBFM approach is progress toward recognising the holistic nature of fisheries systems and the complex feedback linkages that characterise them (Mahon et al., 2008 p. 104).

An EBFM approach has wide support at the international level, and has involved many international organisations in the development of the concept and guiding principles for implementation at the regional and national levels. From the literature the key aspects underpinning EBFM and key elements considered important for implementation were identified. Acknowledging social choice and values are important factors in the decision-making processes, as these can shape governance and management outcomes. As argued by Brussard et al. (1998) the significance of EBFM is that it focuses on ecosystems as a whole, includes public involvement in the planning processes, integrates conservation into economic activity, with a shift towards adaptive management (Brussard et al., 1998 p. 18). EBFM offers an approach to solving complex ecological and social problems (Lackey, 1998). EBFM, however faces the same problems as traditional fisheries management (such as over-fishing, over-capacity, impacts of government subsidies and IUU), but aims to deal with them in a more holistic manner, by placing them in a wider context that takes into account both ecosystem characteristics and fisheries impacts in decision-making processes and management measures (Garcia et al., 2003).

Sustainability depends on understanding how humans and their institutions interact with ecosystems. Understanding the links between human socio-economic systems, and biophysical systems and their characteristics could provide guidance for designing sustainable human systems within sustainable ecosystems (Costanza et al., 2001). The important components of sustainable development and EBFM, includes maintaining biodiversity to avoid foreclosing future options as well as considering economic, social and institutional sustainability and resilience. The environmental, economic and social dimensions and the complex dynamics within and between them is the topic of Chapter 3.

CHAPTER 3: THE ENVIRONMENTAL, ECONOMIC AND SOCIAL DIMENSIONS OF EBFM

3.1 Introduction

Ecosystems goods and services provide opportunities for human wellbeing but are equally important to the natural world that we and other species are dependent upon. In many countries population growth and demographic changes (a trend of more people living on the coastal margins), together with increased coastal development, threaten key fish habitats. The globalisation of the fishing industry has developed new markets and there has been an increase in demand for fish for human consumption, and fish derived products for use in agriculture and aquaculture. Technological changes have increased fishing power and accessibility of new fishing grounds. Collectively these recent changes and drivers are impacting marine ecosystems (Peterson and Lubchenco, 1997). Although the benefits of these changes has led to food security and economic development, it has in some cases impacted upon important ecosystem goods and services, which also pose future risks and costs to both ecosystem and human systems (Srinivassan et al., 2008). The range of oceans and fisheries issues has changed over time and will continue to change, as will the drivers of these changes.

Marine resources such as fisheries and aquaculture provide economic and social opportunities, but global trends indicate an increasing proportion of marine fisheries have become over-exploited or depleted, and this is inconsistent with the goals of sustainable development and Ecosystem Based Fisheries Management (EBFM). Fisheries governance and management face complex problems from both environmental and political perspectives. A policy conflict may arise from the need to address both stock conservation and fishing community concerns in terms of employment and income, with trade-offs between short-term and long-term employment, profitability and stock size (Mardle and Pascoe 2002). An integrated approach to the complexity of managing wild resources is needed (Caddy and Seijo, 2005).

This Chapter provides background to the importance of marine ecosystem goods and services, and why biodiversity is considered to be important to the continued supply of ecosystem goods and services. It describes the unique characteristics of the marine environment and highlights the importance of understanding the key aspects with respect to biodiversity. It identifies the principal issues and major impacts on the marine environment, and describes how fisheries, as one of the major sectors, may affect marine ecosystems. It should be noted, however that fishing and marine resource use are not always detrimental to ecosystems. This discussion will be followed by a discussion on the economic and social dimensions of fisheries. The biosocioeconomic subsystems (of the integrated systems model, as introduced in Chapter 2, and highlighted in Figure 3.1 below), will be further developed.

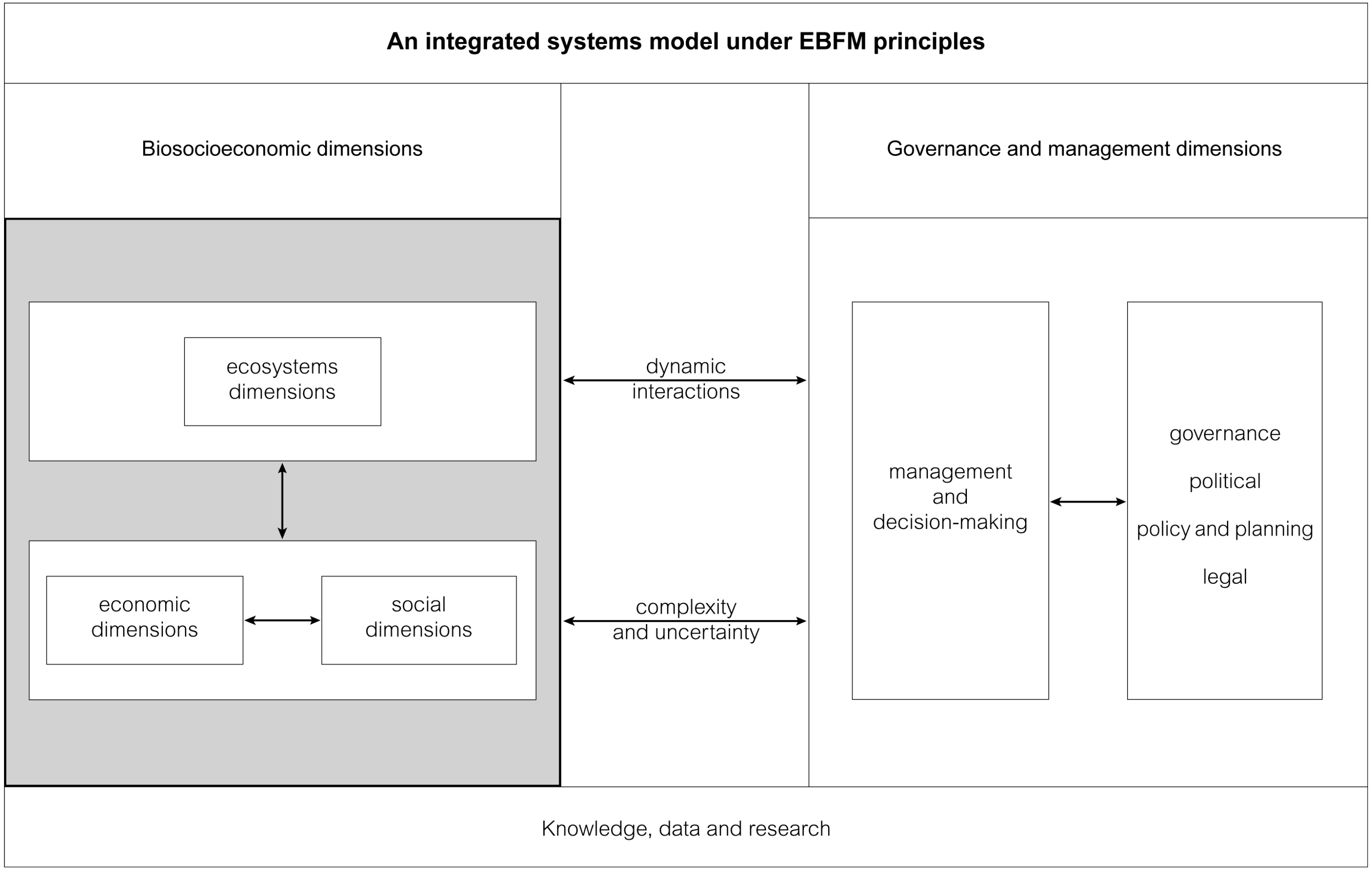


Figure 3.1: An integrated systems model under EBFM principles.

3.2 Environmental dimensions

Marine ecosystems provide a range of important ecosystem goods (primary production) and services (life support functions), which support life on this planet. The expansion of human activities and associated impacts has modified many marine ecosystems (Costanza, 2000). EBFM requires an understanding of the environmental and biophysical dimensions and natural variation in ecosystem conditions; the consideration of both direct and indirect effects of fisheries; and the cumulative effects of human activities that may have the potential to perturb marine ecosystems. This understanding is important as the state of the environment and ecosystems can also affect fish and fisheries production.

3.2.1 The marine environment: its unique characteristics

The oceans cover 70% of the planet and are characterised by different topographic features; diverse ecosystem types and associated assemblages; variations in temporal and spatial patterns of primary production; and complex biogeochemical processes. Environmental variability is a factor in controlling the abundance and distribution of marine species. The variability in the ocean is linked to different coupled physical and biological dynamics that occur at a range of spatial and temporal scales, and are also dependent upon the size and persistence of events. Human activities have also been linked to a range of ecological changes in marine ecosystems, with these effects also occurring at different spatial and temporal scales (Kaiser et al., 2005; Parsons and Harrison, 2000).

Seawater has a capacity for storing heat, which moderates seasonal temperature fluctuations, and this has resulted in the dominance of marine animals that do not regulate their own body temperature (Thorne-Miller and Catena, 1991; Lalli and Parsons, 1993; Nybakken, 2001). Currents, strong gradients in physical properties such as light, temperature, and salinity, may define boundaries between ecosystems. Currents may separate water masses with different environmental conditions, and may act as a physical barrier to small organisms. Biological communities are defined by species vertically clustered in distinct assemblages. Species are distributed in vertical zones depending on environmental factors such as light, temperature, oxygen, and food supply. At the surface is the microlayer, which has a distinct flora and fauna, that is in direct contact with the atmosphere, and where airborne substances, including toxins, are dissolved. If this layer becomes degraded it may impact on adult populations living in deeper water, as the most sensitive life stages of many species are spent in this surface layer (Thorne-Miller and Catena, 1991; Lalli and Parsons, 1993, Nybakken, 2001; King, 2007; Kaiser et al., 2005).

Many aspects of the marine environment remain unknown or are undescribed. Life in the sea is more difficult to observe, and changes may be undetected, particularly where baseline data is not available, making it difficult to evaluate the degree and nature of changes. Understanding these different and unique aspects of marine ecosystems and the impact of human activities (such as fishing and other cross sectoral activities) are important for the continued supply of ecosystems goods and services; maintaining marine biodiversity; and the functioning and resilience of ecosystems (Thorne-Miller and Catena, 1991; Lalli and Parsons, 1993; Nybakken, 2001).

Aspects of marine ecosystem dimensions are outlined in table 3.2.1(a) and table 3.2.1(b), which provides a framework for describing the ecosystem dimensions, components, characteristics and the biogeochemical drivers. Spatial and temporal scales are important in understanding marine patterns and processes. Some processes are local and occur over short time periods, whereas others can occur at larger spatial scales and take many years or decades, for example as in deep ocean cycles. Detailed descriptions are given by Hammond and Synnot (1994); Levinton (1995); Mann and Lazier (1996); Nybakken (2001); Open university (1989); Open University (1994); Open University (1995); King (2007); Kaiser et al. (2005); and Connell and Gillanders (2007).

Table 3.2.1(a): A hierarchical framework of ecosystems dimensions, components and characteristics.

Dimension	Component (type)	Characteristics
Biosphere: ecosystem goods and services		
Biomes	Polar, subpolar, equatorial, tropical, sub tropical, temperate	Pelagic, neritic; oceanic; epi, meo, bathy, abysso pelagic
Oceans and seas of the world	Oceans: Arctic, Pacific, Atlantic, Indian	Benthic; litterol; sublitterol; bathyal; abyssal, hadal
Topography	Ocean structure	Topography – cross sections: plates; ridges; crests; faults; ocean crust; ocean basins; continental margins
		Features: vents, seeps, seamounts
Ecosystem biodiversity, resilience, biomass	Estuaries and salt marshes	Communities
	Intertidal	Species – populations
	Tropical coral reefs, Temperate reefs	Individuals - species
Ecosystem types: specific to geographic area and habitat type	Mangroves	Physical environment:
	Sea grass	Chemical environment:
	Kelp forests	Food chain: primary producers, herbivores, carnivores
Zones: inshore, shelf break, open ocean	Deep ocean	Food web: productivity, primary, secondary, tertiary
Depth: pelagic; benthic shallow to deep	Benthic	Energy and mass budgets
	Seamounts	
	Pelagic	
	Meiofauna	
	Vents and seeps	

Table 3.2.1(a) continued: A hierarchical framework of ecosystems dimensions, components and characteristics.

Dimension	Component (type)	Characteristics
Community: interspecies interactions and composition Associated with habitat types Ecological processes	Water column: plankton, phytoplankton, zooplankton Water column nekton: cephalopods, fish (cartilaginous: sharks, skates, rays; bony fish), mammals (cetacea: whales, porpoises; pinnipeds: seals, walruses, sealions, sea otters; sirenians: manatees, dugongs, sea cows); birds and reptiles (sea snakes, turtles) Benthic: invertebrates (kingdom protista single celled organisms; sponges, hydrozoans, jelly fish, anemones, corals; worms, molluscs); Flora	Competition within and between species resources space and food Trophic structure - predation/prey Assemblages Distribution, composition Structure and function Succession Keystone species
Species: origin new species, extinction of living species, biogeography distribution and abundance structure and function	Species Genus Family Order Class Phylum Kingdom	Life history Reproduction Dispersal Migration Geographic range: habitats, dispersal, provinces Predator/prey Genetic traits: i.e. morphology Adaptation Diurnal
Population size and persistence, genetic variability	Population growth and size (affect limiting resources, biomass) Spatial variation (distribution, density dependence) random, aggregated, patchy, uniform	Mortality and survival rates Generation time Births Recruitment Deaths Immigration/emigration Behaviour
Individual organism's survival under varying physico-chemical conditions, find shelter, mates, avoid predators, and locate food.	Species type	Predation Paritism Competition Territoriality Commnensulism Mutualism

The biophysical processes include ocean circulation; waves, tides and shallow water processes; productivity; and sea-water composition, properties and behaviour (Mann and Lazier, 1996). The biogeochemical processes involve a throughput of energy and a cycling of nutrients (Kaiser et al., 2005). The spatial and temporal scales of observation can influence the patterns that can be detected and the interpretation as to how these are generated and maintained (Karlson, 1999). As Nybakken (2001) explains "all organisms interact with their own species, other species, and the physical and chemical environments that surround them. In this interactive process, the organisms have effects on each other and the surrounding environment. Similarly, different factors of the environment affect the activities of the organisms" (Nybakken, 2001, pp. 15-16).

Table 3.2.1(b): A representation of the biogeochemical processes.

Biogeochemical processes	
OCEAN CIRCULATION *Atmosphere and the oceans* radiation balance earth/atmosphere system incoming/outgoing by latitude global wind system winds and zones of low/high pressure prevailing winds *Ocean currents* surface currents (cool and warm) wind system and coriolus effect major currents, streams, gyres areas upwelling	 *Global fluxes and the deep circulation* oceanic heat budget, seasonal oceanic water masses (upper and intermediate) deep and bottom water masses water mixing
WAVES, TIDES, SHALLOW WATER PROCESSES *Waves* types, forms, dispersion and spread, energy *Tides* the earth moon system the earth sun system dynamics of tides types of tides	 *Shallow water environments and sediments* supply and distribution *Sediment movements by waves and currents* fluid flow sediment erosion sediment transport deposition sediment seabed forms

Table 3.2.1(b) continued: Hierarchical representation of ecosystems dimensions, components and characteristics, and biogeochemical processes.

Biogeochemical processes	
PRODUCTIVITY *Primary* phytoplankton, zooplankton *Factors affecting primary production* physical and chemical, light, nutrients geographical variability, inshore/offshore seasonality	*Food chains and webs* trophic levels and groups Keystone species *Microbial loop*
SEA WATER COMPOISTION, PROPERTIES *Hydrological cycle* *Carbon balance* *Temperature* major biogeographical regions oceans distribution of temperature with depth annual variations thermal layers *Salinity* distribution with depth distribution of surface salinity *Density and pressures* water masses boundaries of upper water masses mixing processes	depth, pressure, density and temperature *Light and sound* light penetration and depth underwater sound *Seawater solution* chemical composition particulate matter nutrients phosphate, nitrogen, carbon cycle, microbial loop *Chemical and biological reactions in seawater* carbonate system alkalinity and PH control minor and race elements *Seawater and the global cycle*

3.2.2 The importance of marine ecosystem goods and services and biodiversity

Daily (1997) defines ecosystems as a set of organisms living in an area, their physical environment, and the interactions between them. Ecosystem services are the conditions, processes and species that sustain life on this planet. Tilman (1997) argues that biodiversity is thought to influence the supply of ecosystem goods and services. Biodiversity is described as the variety of life at all levels of organisation, from genetic variation within and among species, to the level of variation within and among ecosystems, and biomes.

Human activities are changing many ecosystems, some of these activities have resulted in benefits to humans in terms of food security and economic development, but these changes are now threatening ecosystem goods and services, and economic and social options, for current and future generations. The 2005 Millennium Ecosystem

Assessment reported that 60% of ecosystem services surveyed are being degraded or used unsustainably (Srinivasen et al., 2008). Ecosystems respond differently to disturbance, and ecosystem stability may depend on biodiversity. Some ecosystems are not greatly impacted whereas others can be susceptible to disturbances, which may lead to a loss of productivity, and functioning of these ecosystems. The harvesting of species from ecosystems, such as fish, may be carried out on a sustainable basis (maintaining ecosystem function and biodiversity), or adverse practices might lead progressively to lower ecosystem productivity and biodiversity. The degradation of ecosystems pose a threat to maintaining ecosystem goods and services, so maintaining biodiversity and ecosystem sustainability is considered important, for both human and environmental well being (Tilman, 1997 pp. 93-109).

As Kaiser et al. (2005 p. 20) explain there are three main aspects of biodiversity ecological (biomes, ecosystems, habitats); organismal (kingdoms, phyla, species); and genetic (populations, individuals and genes). Diversity also occurs at a number of different levels – genetic, species, phyletic, functional, community, ecosystem and habitat, but all are important to marine biodiversity. There are also different spatial and temporal patterns of diversity (Gray, 1997). Conservation of biological diversity has been a major focus of recent international forums. As it is recognised that if biodiversity concerns are not taken into account, and the products and services provided by biodiversity are not harvested on a sustainable basis, future options may become limited. In 2002 parties to the Convention on Biological Diversity (CBD) committed to actions to achieve by 2010 a significant reduction of the current rate of biodiversity loss at the global, regional and national levels. In 2004, the Biodiversity Liaison Group was created under five of the key global biodiversity related conventions (UN Convention on Biological Diversity, Convention on International Trade in Endangered Species, Convention on the Conservation of Migratory Species of Wild Animals, Ramsar and the World Heritage Convention) to help facilitate a more co-ordinated approach to policy development and implementation (Kaiser et al., 2005 p. 491; United Nations Environment Programme (UNEP), 2007 pp. 160-189).

Although the understanding of the importance of biodiversity has developed over the past twenty years, biodiversity decline and loss has continued. Some biodiversity losses such as erosion of genetic variability in a population are often slow or gradual, and may not be recognised until too late. Biodiversity loss continues because the values of biodiversity are insufficiently recognised by political and market systems. An added complexity is that the global nature of many biodiversity values, result in the loss being felt beyond national boundaries. While technological alternatives to some services provided by biodiversity are available, these are more costly when compared to those benefits derived from functioning ecosystems (United Nations Environment Programme (UNEP), 2007 pp. 160-189). The goods and services flowing from ecosystems are often undervalued by society, and their value has primarily become a focus of attention due to their disruption and loss, and a growing awareness of the limits and cost of technological substitution (Daily, 1997 pp. 2-7).

Charles (2001 p. 32) describes natural capital in terms of ecosystem goods and services, which are critical to the functioning of the planet, and that fish stocks are only one part of the natural capital in the marine environment. Because ecosystem services are not captured in markets, their full value, are often not considered fully in the decision-making process. In 1997 Costanza et al. (1997) estimated that ecosystems provided at least US$33 trillion dollars worth of services annually, and most of this value was outside the market system. About 63% (US$20.9 trillion) of the estimated value was contributed by the marine system, with most contributed by coastal systems (US$4.7 trillion).

Costanza et al. (1997) acknowledge that these estimates have limitations as it is based on a static snapshot; it does, however, serve to highlight a number of important factors. In many respects the value of ecosystem services to the economy is infinite, and the interdependent nature of ecosystem functions and services are critical for human welfare. An important question is how changes in the quantity or quality of different types of natural capital and ecosystem services, may impact human welfare. The issue of valuation is linked to choices and decisions made by society about ecosystems. Costanza et al. (1997) suggest if ecosystems services were fully accounted for in the global market system, the global price system, and Gross National Product (GNP) would be different, as would the appraisal of the costs and benefits of particular human activities.

3.2.3 Marine ecosystems and biodiversity

Ecosystem types are often specific to a geographic area and associated with a particular habitat types. These play different but important roles and provide a range of environmental, economic and social benefits. There is a latitudinal pattern of diversity with an increase in species diversity of hard substratum epifauna from the Arctic to the tropics. The Arctic is much younger and has low biodiversity and low endemism compared to the Antarctic. Production processes also differ, the Arctic is dominated by many commercial fish species, whereas the southern ocean is characterised by invertebrates (krill and squid) which support birds and mammals and only small fisheries. In the southern hemisphere the pole to tropic gradient is less clear as the Antarctic has high diversity for many taxa. The longitudinal pattern of tropical diversity for coral genera and species have highest values in the Indonesian archipelago and falling values westward across the Pacific Ocean. It appears that the Indonesian archipelago is the epicentre for evolution of marine tropical biodiversity, which is thought to be the result of a large diversity of island types and archipelagos (Gray, 1997 pp. 159-160).

Diversity within ecosystems is important for stable function and productivity, and high levels of fishing mortality may reduce diversity in a system, or alter long-term responses of ecosystems. Fishing can affect many species and linkages in ecosystems and any reduction in biodiversity could affect an ecosystem’s ability to withstand change, and it may instead undergo a major shift in trophic structure, composition and function (Fulton et al., 2004 p. 13). It is therefore important to understand what impacts an ecosystem can withstand before major changes occur and how reversible these are. Alteration or disturbance of one or several components of marine ecosystems can for example have effects on higher or lower trophic levels, depending upon whether food webs are controlled by predators, top down processes; or resources, bottom up process; or small pelagic fish, termed wasp waist control (Curry et al., 2003 p. 104).

3.2.4 The marine environment: principal issues and impacts

The Committee on Biological Diversity in Marine Systems (1995) highlighted that marine biodiversity is changing, and unless there is a change in human attitudes it is likely human-mediated extinction of species in the sea will be similar to those on the land. The loss of species has been part of the earth's evolutionary history through natural events. Over time some changes were reversible, and others were integrated through a process of adaptation. Human mediated changes, however, are often irreversible, affecting many different habitats, occurring within shorter time frames, and the order of magnitude of change is often higher (Thorne-Miller and Catena, 1991 pp. 14-16; the Committee on Biological Diversity in Marine Systems, 1995 pp. 5-7). Many marine ecosystems are already highly stressed and may not be able to cope with new and increased stresses, which may lead to further loss of biodiversity. In the past the rate of change has been slower, often allowing for adaptation. This may be a particular problem for the flora and fauna of the deep oceans, which have until recently experienced relatively stable conditions and may not be able to respond to rapid changes (Thorne-Miller and Catena, 1991 p. 15). There are a number of human activities that can directly or indirectly impact marine ecosystems, which in turn may also affect commercial fisheries and aquaculture. Ecosystem-based management requires the consideration of both direct and indirect effects of commercial fishing as well as the inclusion of other impacts such as bycatch, and recreational fisheries. The combined effects of, fishing, environmental variation, and climate change increasingly threaten marine ecosystems, and complicates management (Crowder et al., 2008). The principal issues are climate change; coastal development and land-based impacts; and the direct and indirect impacts of fishing and these will be discussed below.

Climate change

The environmental and biophysical impacts of climate change include the warming of ocean waters, sea level rise and ocean acidification; changing weather patterns and rainfall with more extreme storm and cyclone events; changes in ocean currents and waves; chemistry changes in ocean waters; and in coastal areas erosion of the shoreline. Productivity patterns, ecosystem boundaries and species composition may also change (Voice et al., 2006). Climate change may affect aquatic ecosystems in many ways, although the capacity of fish species to adapt to such change is not fully understood. Changes in water temperatures and especially in wind patterns, however, suggest climate change can disturb fisheries, with potentially serious impacts on global fishery resources (United Nations Environment Programme (UNEP), 2007 p. 122). Concern with the projected rapidity of current climate change centres on whether, species and ecosystems have time for adaptation. This is an emerging problem, which has already reached an irreversible turning point in terms of current human planning time frames. Stabilisation of greenhouse gas concentrations is yet to be achieved, and even when stabilised, warming is likely to continue for centuries, but at a slower rate, while sea levels will continue to rise unabated for many centuries (Pittock, 2003 pp. 3-4).

As a consequence of ozone depletion, UV-B radiation is increasing which may reduce productivity of phytoplankton in surface waters in the open ocean (Gray, 1997p. 163). There is also the threat of global warming through the impact of increased greenhouse gases most notably, but not restricted to carbon dioxide CO_2. This is due to industrial processes such as the burning of fossil fuels, and the widespread clearing of tropical forests. Although it is difficult to predict outcomes, it is likely there will be changes in climate and weather patterns with more frequent storm events and changes to rainfall patterns. There will also be a rise in sea level through expansion of the oceans and increased melting of the ice caps. These changes pose risks to many species that have low temperature range tolerances, such as corals; and for those species where sea level rises will result in the loss of critical coastal habitats (United Nations Environment Programme (UNEP), 2007 p. 59). An outcome of the continued increase in levels of atmospheric CO_2 will be a decrease in carbonate ion concentrations and an increase in hydrogen ion concentration; this will reduce the ability of oceans to absorb CO_2, resulting in acidification of the oceans. Acidification will decrease planktonic and benthic habitat calcification rates for individual species and coral communities (Sabine et al., 2004; Feely et al., 2004).

Climatic factors can affect the spatial extent of marine populations by modifying the dynamics of the spawning or feeding areas, consequently changing recruitment success and migration patterns. The inter-annual environmental fluctuations such as El Nino events affect the structure of the plankton community, the spatial distribution of fish and invertebrates, the recruitment success of pelagic fish and the mortality of birds and mammals in the northern Pacific. Alternate patterns between two small pelagic fish species, sardines and anchovy, have been observed on a decadal basis in upwelling systems (Curry et al., 2003 pp. 104-110). Climate change will affect the ocean environment and its capacity to sustain fish stocks. The situation is likely to be made worse in conjunction with other stresses such as land-based activities and impacts from fishing. According to the FAO (2009 pp. 87-87) in general the impact of climate change (which may be positive or negative) on fisheries, aquaculture and coastal communities will depend on the vulnerability of each community. The factors determining vulnerability include the nature and degree of exposure to climate change and the degree to which communities are dependent upon fisheries and their sensitivity to changes in the fishing sectors, the potential impacts to fisheries and livelihoods, and the adaptive capacity of communities.

Coastal zone development and land-based impacts

Many of the major threats to marine biodiversity are in the coastal zones, as a result of increased population densities in coastal areas, together with coastal development and urbanisation. In developed countries this is driven by lifestyle choices, whereas in developing countries it is more from population pressures and economic necessity. The coastal zone is also subject to multiple uses and users such as: port infrastructure for shipping and transport; tourism and recreational activities; oil and gas production facilities; waste disposal; and fishing and aquaculture. These activities can modify or damage marine habitats. Pollution from land-based activities also effect water quality. The cumulative impacts resulting from these activities have the potential to affect marine biodiversity, ecosystems and fisheries production (Gray, 1997; Rosenberg, 2003 p. 189; Kay and Alder, 2005 pp. 21-44). Three key issues are habitat modification or loss; water quality and pollution; and the introduction of exotic marine species.

Habitat loss and modification can occur directly through land reclamation as for example the draining of coastal salt marshes or the removal of mangrove forests; or may occur indirectly through human activities and the associated consequences of coastal development, such as eutrophication. The coastal marine environment is particularly vulnerable to both these pressures. Some habitats are important to particular species during the different stages of their life history such as providing food, shelter, safety, suitable spawning sites and juvenile nursery grounds. Some habitats are associated with particular species, for example seagrass and dugongs, therefore the loss of critical habitat may threaten particular species (Martha et al., 2002 pp. 341-358).

Chemical pollution and eutrophication are a cause of water quality issues. Organic and inorganic wastes from land-based activities such as agricultural, industrial, and domestic wastes particularly affect estuaries and coastal areas. Nutrient pollution can cause harmful algal blooms (Hughes and Goodall, 1992; Suchanek, 1993; Suchanek,1994; Rosenberg, 2003). Many of these chemicals react with the chemistry of seawater, which in turn may affect organisms that live and feed in these waters, also allowing toxins to enter the food chain. The effects of contaminants may not cause direct mortality, but may have negative population effects on recruitment processes and larval viability, or cause abnormalities in growth and reproduction. For example, coral reproduction processes are highly sensitive to decreased water quality and persistent pollution. Some heavily polluted estuaries have already lost much of their flora and fauna. Deep sea habitats may also be altered by pollution as the sea continues to be used for waste disposal, some of which is highly toxic (Thorne-Miller and Catena, 1991 pp. 17-19; Kay and Alder, 2005 pp. 21-44; Kaiser et al., 2005 pp. 476-483; Harrison and Booth, 2007 p. 355). The damming or diversion of rivers for power generation, flood control or irrigation has resulted in significant reductions and/or changes in the timing and amount of freshwater flowing to the sea. Reduced sediment flows into deltas and wetlands, has in some cases resulted in the loss of fish spawning habitat. Other activities such as mining or deforestation have led to large increases in sediment loads, which can smother coral reefs and other coastal habitats important to fisheries production (McKay et al., 1999; Gray, 1997).

The translocation of exotic species has the potential to alter entire ecosystems and habitats which may cause highly specialised native species to become vulnerable through competition and predation. Exotic species may also introduce parasites and diseases that native species have no immunity to, in some cases this may prove fatal. The difficulty is that once exotic species have become established, it is virtually impossible to eradicate them. The primary vectors for introductions are through the ballast water from commercial ships, the hulls of boats, and the aquaculture industry. The effects of invasive species are considered one of the main threats to native biodiversity, together with habitat destruction and modification. Disturbed terrestrial environments can facilitate animal and plant invasions, the extent to which this may also be the case in marine environments, particularly in disturbed coastal zones, is only beginning to be investigated (Meffe and Carroll, 1994; Glasby and Creese, 2007). Genetically modified species from aquaculture may escape or be introduced to the wild and interact, compete or breed with its wild counterpart. For example, reared salmon for aquaculture has caused issues for wild salmon fish stocks in several countries (Richardson, 2003 pp. 278-279).

Impacts of fishing on marine ecosystems

Fishing affects the targeted fish stocks and other ecosystem components, directly or indirectly (Holmlund and Hammer, 1999; Sissenwine and Mace, 2001). Marine fish stocks show evidence of declines from a combination of unsustainable fishing pressures, habitat degradation and global climate change (United Nations Environment Programme (UNEP), 2007 p. 145). The potential for fishing to impact ecosystem components directly or indirectly is now recognised. The direct impacts of fishing include the mortality of target species; non-target species caught as bycatch; and discarding and high grading practices. Total species mortality (both natural and fishing) can fluctuate considerably, and may be more extreme in one year than another due to environmental conditions, such as changes in water temperature; lack of food; competition; population density; predation; pathogens and disease (Fulton et al., 2004 pp. 7-10).

Direct impacts of fishing

Fishery systems are complex and subject to natural variation, and perturbations from human activities (including fishing), therefore yields are not constant. If annual stock assessments do not account for these variations, over-exploitation may occur. If this situation continues some populations may not be able to recover, especially in the case of long-lived slow-growing species. The outcome is that stocks may fall below the minimum viable population level (pushed past the ecological threshold, the allee effect), so even when management reduces fishing pressure stocks are slow to recover, or in some cases may not recover (Barbier et al., 1995).

Exploitation of commercial target species may result in demographic changes such as reduced population size, changes in size and age structure of populations and community changes. The direct impacts of total mortality (natural, targeted catch, and bycatch /discards) on species can impact communities, populations and species components within an ecosystem in the following manner. Declines in slow growing species with low fecundity may over time result in community changes within an ecosystem, to one dominated by highly productive and fast growing species. Fishing usually selects the larger and older fish, which can affect productivity (fecundity), as the larger and older individuals, usually have a greater reproductive capacity. This selective pressure on populations may change the size and age structure of a species leading to a reduction in genetic fitness. This in turn reduces the ability of a population to withstand fluctuations due to natural variability or other human activities, which further stresses and weakens ecosystem components (Fulton et al., 2004 pp. 7-8; Kenchington, 2003 pp. 235-240). One effect of over-fishing on community composition is fishing down marine foods webs (Pauly et al., 1998). This can occur where fishing fleets switch to new target species at a lower trophic level, thus leading to sequential over-fishing. Fishing can also disrupt foraging behaviour and reproduction of some species. Reproductive potential may be reduced for some fish and invertebrate species, by removing individuals from spawning migrations or aggregations, but also by causing aggregations to disperse or decline to densities at which they are ineffective (Fulton et al., 2004 pp. 7-8).

Although commercial fishing targets particular fish species, many non-target species are also caught as bycatch – depending on the fishery method and gears, which may then be discarded. Quantifying actual amounts of discards may be difficult globally, as these statistics are not required in many fisheries, or may be difficult to verify where there are no observer programs. Therefore, mortality will be underestimated, and in some fisheries bycatch and discards may be larger than the landed catch. Different fishing techniques and gear types can lead to distinct and different types of bycatch, including incidental mortality (Goni, 2000). For example, shrimp trawls have a high bycatch rate due to small mesh nets used, retaining a large variety of fish that are found in the same habitat (Cook, 2003 pp. 220-223). Bycatch species may include other non-target fish species, invertebrates, marine mammals, reptiles, and birds. The loss of species at one level of the food chain could dramatically affect species at another level, as marine food webs can be very complex. Bycatch mortality is a serious problem due to its magnitude in terms of the removal of biomass and the range of species affected. This can be a problem particularly for slow growing species with low fecundity, those that have a limited geographical range, or are dependent upon particular habitats during different stages of their life history (Kaiser and Jennings, 2002 pp. 342-361). Bycatch problems in a fishery can also be a symptom of resource over-exploitation. Bycatch resulting from technological constraints imposed by gear may be made worse by economic forces that drive the process. For example, the process of reducing selectivity to catch smaller fish so that profitability can be maintained will result in greater bycatch of small non-target species. As abundance of target species becomes less, in order to maintain catch rates fishers will extend the range of species taken and the geographical areas fished (Cook, 2003 p. 228).

Discarding may occur because the species caught do not have any commercial value, or regulations may prohibit the landing of certain species. High grading is the discarding of marketable species in order to retain the same species at a larger size, or higher price (Hall, 1995). Discarding can impact energetic pathways and community structure by increasing opportunistic scavenging, which may change the foraging patterns of certain species, leading to changes in predator/prey strategies. Discarding may also increase susceptibility to disease of individuals damaged by gear interactions, as well as the spread and introductions of pathogens due to changing local environmental conditions. Discarding can change chemical and ecological conditions as discards form deposits of organic material with high oxygen demands, and may lead to anoxic conditions in benthic environments that receive poor circulation (Fulton et al., 2004 pp. 9-12).

Indirect impacts of fishing

It is only recently that the indirect effects of fishing activities on other species and exploited ecosystems have been recognised, and are now of concern to a wide range of stakeholders (Fulton et al., 2004; Goni, 2000). Indirect impacts of fishing may include ghost fishing, community changes, habitat modification, and an increased susceptibility to environmental fluctuations. Fishing may affect community structure, competition and predator prey interactions may be changed, and may cascade through the food chain either by bottom-up or top down controls. Fishing operators often accidentally lose gear (nets or traps) or dump other debris used by the fishery (plastics). Lost fishing gear may cause mortality by continuing to catch fish (ghost fishing) for a long time afterwards ranging from days, months to years depending upon the depth, habitat type, current speed, and the longevity of the materials of gear, such as gill nets and traps. Marine litter and debris such as damaged nets and plastics may cause mortality by entangling mammals such as seals or turtles, or by ingestion, for example seabird chicks and light sticks (Fulton et al., 2004 pp. 8-9).

Fishing occurs across most marine ecosystem types, and may be associated with particular habitats. The deployment of fishing gear on these habitats and destructive fishing practices modify habitats by disturbance or destruction. For example trawling or dredging on the sea bed can impact benthic species, topographical structures and sediments. Blast fishing, poison, and drift can cause high indiscriminate mortality, affect coral reefs, and recovery may take a long time. These practices impact the complexity, structure, function and composition of these ecosystems (Hall, 1999). Different forms or aspects of habitat complexity can be important to different life history stages or species. Impacts to habitats and ecosystems may result in changes to the productivity of target and non-target species, as habitats become unsuitable for particular species. Sediment resuspension and disruptions to sediment based nutrient cycling and digenesis can affect the composition and productivity of the overlying water column community (Fulton et al., 2004 p. 9).

3.3 Economic dimensions

The oceans have been a source of food and other marine resources benefiting humans throughout history (WWF/IUCN, 1998). The abundance and distribution of many commercial fisheries has changed due to over-harvesting, and some fisheries are no longer commercially viable (McGoodwin, 1990). Fisheries world-wide are suffering large losses in potential economic productivity, with excess costs over revenues. Economic losses include loss of earnings, unemployment, higher retail prices, underused capacity due to over investment and subsidies. Subsidies for vessel construction and operation have signalled artificially low costs to harvesters and investors, and have led to an expansion in gross tonnage of the world’s fishing fleet between 1972 and 1992. These subsidies have masked signals of scarcity and have led to over-use of marine resources. The combination of fisheries development under open access conditions, expanding seafood markets, technological innovations, and government subsidies has resulted in a major change in the status of world fisheries (Hanna, 1999).

At the beginning of the post Second World War period 60% of world fisheries were unexploited, but by the 1990s 60% were fully or over-exploited. This change has implications for biological, economic, social and management implications (Hanna, 1999). Since the 1950s globalisation has played an important role in the development of fisheries, with the emergence of large-scale industrialised fishing operations and international trade for fish products. These technological and economic changes have affected the development of fisheries world-wide, and the ecosystems that support these fisheries. During this same time period, there have been social changes with continued population growth, together with an increased demand for fish as protein for human consumption. There has also been an increased demand for other marine and fishery products, for agricultural purposes, such as the use of fishmeal for feeding livestock; and the development of aquaculture has also increased the demand for fishmeal (Chuenpagdee et al., 2005 pp. 27-30).

The utilisation of world fisheries production (inland and marine capture and aquaculture), provide food for human consumption (77%) and non-food products (23%) such as fish meal and oil, used for agriculture and aquaculture feed. Fish and fishery products are highly traded and world exports for 2006 were US$85.9 billion. In real terms (adjusted for inflation) exports have increased by 32.1% in the period 2000-2006. In 2006 world fish imports were US$89.6 billion, an increase of 10% on 2005, and 57% since 1996. There are differences in regional trade flows in terms of net imports or exports and overall net trade surplus or deficits, as well as the types and categories of fish products traded. Prices of fishery products followed the general upward trend of all food prices during 2007 and early 2008. In world markets the trade focus was mainly on high value species (shrimp, salmon, tuna, gadiformes, bass and bream), but a number of high volume but low value species are also traded in large quantities, both within major producing areas and internationally. The management of global marine fisheries is a challenge and the potential economic benefits from effective management was the subject of a recent “Rent Drain” study (a joint project of the World Bank PROFISH global program on fisheries and FAO) that shows the difference between the potential and actual net economic benefits from marine fisheries is approximately US$50 billion per year. The cumulative economic loss to the global economy over the last three decades (1974-2007) is estimated at US$2.2 trillion. The study also mentioned that the focus on the declining biological health aspects has tended to obscure the economic health of fisheries, which are considered fundamental to achieving the restoration of fish stocks and improved livelihoods, exports, fish food security and economic growth (FAO, 2009 pp. 6-7, 45, 49, 53-54, 66-67).

The economic dimensions of fisheries include the fishery production and fishing methods; the fishery sectors and fishing fleets and technology; the post harvest sectors; and the economic macro and micro drivers. The economic dimensions of fisheries, as outlined in table 3.3, provides a framework for describing the economic dimensions, components, characteristics and macro and micro drivers.

Table 3.3: A framework for identifying and describing fisheries economic dimensions, components, characteristics and macro and micro drivers

Dimensions	Components	Characteristics	Economic drivers
Resources	Targeted species Fish Crustaceans Molluscs Echinoderms Elasmobranches Porifora	Pelagic or benthic species and their associated ecosystems and habitats Population dynamics and natural variability	*Macro economics* Trade Exports/imports Markets international, domestic, local Supply and demand Gross Domestic Product
Fishing methods	Seines/encircling Trawls and dredges Gillnets Traps and pots Hook and lines Divers	Pelagic or benthic deployment associated with particular ecosystems and habitat types	Balance of payments Comparative advantage Production and growth Macro economic objectives *Micro economics* Trans national corporations
Fishery sectors	Commercial Small scale Large scale Aquaculture Subsistence Indigenous Recreational/charter	Inshore Offshore High seas Fishing seasons Knowledge and experience, training	Domestic firms Small business or single operators Supply and demand Prices Profits Fixed costs and overheads
Fishing fleets and technology	Capacity: Inshore Offshore High seas	Single boat operator Local fleets Corporate fleets Old/new fleets On board technology and equipment	Capital and investment Resource access and user rights Competitive advantage Labour Alternative livelihoods
Post harvest	Processing Marketing Distribution Wholesale/retail Consumers	Quality and value added products Consumer preferences Ecolabelling	Micro economic objectives

The status of fisheries and the economic value of fishery resources, to both fishers, and to nations are affected by macro and micro economic drivers, both current and historical. The dynamics of the economic dimensions operate at a range of spatial scales (local, national, regional and global) and temporal scales. Many of these aspects have been discussed in detail by the following authors: Charles (2001); Gans et al. (1999); Stonecash et al. (1999).

3.3.1 Fishery production and fishing gear and methods

The top ten producer countries in 2006 for marine and inland capture fisheries were China (which remains the highest producer) followed by Peru, USA, Indonesia, Japan, Chile, India, Russia, Thailand, and the Philippines. Four fishing areas accounted for about 66% of world marine catches in 2006. These were the northwest Pacific, which is the most productive area accounting for 26% of total marine catches, followed by southeast Pacific (15%), western central Pacific (14%) and the northeast Atlantic (11%). The top ten marine capture fisheries production (from highest to lowest) were anchoveta, Alaskan pollock, skipjack tuna, Atlantic herring, blue whiting, chub mackerel, Chilean jack mackerel, Japanese anchovy, largehead hairtail, and yellowfin tuna (FAO, 2009 pp. 11-12, 33).

Choice of fishing gear and methods depend on the biological characteristics of the targeted species for example whether species aggregate or school (Charles 2001). Fishing gears are termed passive or active and are deployed in the water column or benthic habitats. Passive fishing gears include traps or pots used to catch fish (e.g. snapper) and crustaceans (e.g. lobsters) and are deployed on the sea floor. Gillnets are held vertically in the water column, and may be anchored in shallow water, or set to drift in the open ocean to catch fish (mullet and mackerel in shallow water; demersal species such as sharks in deeper water and on the sea floor; and pelagic species such as tuna in near surface waters). Longlines are used to catch fish e.g. Patagonian toothfish by bottom longliners; and tuna by surface suspended longlines (King, 2007 pp. 140-149; Charles, 2001 pp. 50-52; Kaiser et al., 2005 pp. 410-411). Active fishing gears include towed nets and dredges and are deployed in the water column or benthic habitats. Seines and encircling nets are deployed for catching pelagic schooling fish (such as tuna, mackerel, pilchards, anchovies); and Danish seines are used for bottom dwelling species in deeper water (such as flounder). Mid water trawls and benthic trawls are used to catch a large variety of demersal and deep water species. Towed dredges are deployed in benthic habitats for scallops. Hand methods include spears and hand collection by divers (King, 2007 pp. 140-149; Charle,s 2001 pp. 50-52; Kaiser et al., 2005 pp. 410-411). The mean discard rate by principal gear type, are from highest to lowest: shrimp trawls (12kg); non-pelagic fish trawl (3kg); pot/trap (2kg); longline and Danish seine (1-2kg); and purse seine and pelagic fish trawl (less than 1kg) (Cook, 2003 p. 223).

As outlined above commercial wild caught fishing involves a wide range of gear types and fishing techniques, and deployment in different ecosystems. While commercial fishing targets, particular commercial species, other species are caught and may be discarded. The problem is widespread, with 1998 global estimates of discards at up to 20 million tonnes annually, which accounts for one fifth of total world catch. Although a time series at the global level is not available, evidence suggests that there has been a substantial reduction in discards since the 1994 assessment. This may be due to: the use of more selective fishing gears; the introduction of bycatch and discard regulations; improved enforcement of regulatory measures; and the increased retention of bycatch species for human or animal consumption (FAO, 2004 pp. 122-126). However, as discussed by the FAO (2009), there are concerns that bycatch and discards may be contributing to biological over-fishing and altering the structure of marine ecosystems. There is no commonly accepted definition of the term bycatch therefore any estimate of bycatch requires a statement of which definition has been used (including pre catch losses – unobserved mortality, retained catch and discards). For example the FOA definition does not include retained non-target species or unobserved mortalities and will therefore result in a lower estimate. The EBFM approach to fisheries requires that discards are minimised and pre catch losses reduced. However, there are few management regimes that regulate and report on retained or discarded bycatch species, which impedes progress in understanding and managing this issue (FAO, 2009 pp. 74-76).

More recent bycatch concerns include the incidental bycatch and mortality of endangered or threatened species such as marine mammals, seabirds and turtles. In response there have been efforts to modify gear and fishing practices without a negative effect on the profitability of the fishing operation. Examples of successful developments include turtle excluder devices (TEDs) in shrimp trawls, which have reduced the mortality of endangered turtles; bycatch reduction devices (BRDs) such as sorting grids and square mesh panels have reduced bycatch and discard of finfish in shrimp fisheries; changes in the construction of tuna purse seines has reduced the mortality of dolphins captured incidentally; and technical measures have been introduced to reduce the incidental bycatch of seabirds by long liners. Other measures include hook designs, soak times, and various gear deployment practices. The development of gear modifications for gears that impact habitat are still under development. It should be noted that many of the gear modifications have been initiated by the fishing industry, but any measures and techniques which increase costs and reduce earnings will be unattractive to fishers (Valdemarsen and Suuronen, 2003 pp. 321-341). Spatial and temporal closures are another method that can be used to mitigate bycatch problems (Cook, 2003 p. 231).

3.3.2 Fisheries sectors, fishing fleets and technology

Fisheries resources are exploited by commercial, recreational including charter, and subsistence/indigenous fishers, and by the aquaculture sector. The typology of the fishing vessels and fleets are diverse, and the uptake of sophisticated technology is increasing in all sectors.

Commercial wild caught fisheries

The global state of exploitation of wild caught fishery resources in 2007 was classified as follows, over-exploited (19%); depleted (8%); recovering from depletion (1%); fully exploited (52%); moderately or underexploited (20%). Most of the stocks of the top ten species which together account for 30% of world capture fisheries production in terms of quantity are fully exploited or over-exploited. The areas with the highest proportion of fully exploited stocks are the northeast Atlantic; western Indian Ocean and the northwest Pacific. Overall 80% of the world fish stock (for which assessment information is available) are reported as fully exploited or over-exploited, suggesting that the maximum wild capture fisheries potential has been reached requiring a precautionary management approach (FAO, 2009 p. 7).

Although formal assessments are not available, FAO analysis indicates that about 30% of the stocks of highly migratory tuna and tuna like species; more than 50% of highly migratory oceanic sharks; 66% of the straddling stocks and other high seas fishery resources are over-exploited or depleted (Maguire et al., 2006 p. iv). Technology advances such as gear and cold storage systems has allowed the development of industrial tuna fisheries operating entirely or partially on the high seas, caught with purse-seine or longlines that operate over wide areas of oceans. These fisheries are very dynamic and fleets, especially distant water fishing fleets, can respond quickly to changes in stock size, or market conditions. The high value of tuna and the global nature of fleets and markets intensify concerns regarding excess fleet capacity and increased over-exploitation and stock depletion (Majkowski, 2006 pp.163-173).

The history of commercial fisheries development as outlined by Hall (1999), suggests that from the Second World War until 1958 there was a period of intense fisheries development; and between 1959 and 1972 there was a rapid geographic expansion of fisheries and an increase in catch levels. Since 1972 although catches have continued to increase many stocks have deteriorated. Technology as discussed above has also played an important role in the development of commercial fisheries. There has been a significant increase in fishing power. Larger vessels have allowed expansion of offshore fisheries and harvesting at greater depths. The development of navigational aids (global positioning systems and radar) and communications (with satellite-based systems providing contact and data) allows an increased geographic range and longer periods at sea. The introduction of sophisticated electronics such as echo sounders, sonar acoustics, and net sounders (for tracing fish aggregates), allows focused targeting, and increases fishing effort efficiency (Hall, 1999 pp. 3-14).

Fishing technologies have advanced since the 1950s, which has improved and changed both fishing capacity and fishing power. These include fishing techniques, vessel design, electronic equipment, and materials (Garcia and de Leiva Moreno, 2003 pp. 10-11). Commercial fishers continually adapt fishing activities in response to changing management conditions through physical inputs of production (technology development) and the way these inputs are used to harvest target species. The introduction of new gear and technology includes larger technological investments (acoustics and electronic navigation tools) and smaller stepwise improvements to gear (stronger netting, changes in design of trawl panels) which in combination result in changes in a fishing vessels, capacity over time (Marchal et al., 2006). There is a strong incentive for operators to adopt new technologies and substitute uncontrolled inputs for the controlled inputs, resulting in effort creep. Effort creep is the term applied to the continual increase in catching power that occurs in fisheries as a result of technical innovation or the uptake of unregulated fishing inputs (allocative efficiency) and improvements in technical efficiency. Effort creep can also result in over-capacity and if the problem of over-capacity is not addressed it will lead to a running down of fishstocks and the dissipation of economic returns (Newby et al., 2004 pp. 8, 11, 16). With the recent rise in diesel fuel as discussed by FAO it has been suggested that the economics of the fishing industry, particularly with regard to distant water fishing fleets, might change (FAO, 2007 p. 27).

Recreational and charter fisheries

Recreational fishing is often imagined as people fishing off their local pier, or in small boats mainly inshore close to their local coastal community. While this is still the case there has also been an uptake of sophisticated gear technology in this sector. Recreational fishing, including charter fishing, has become a new growth and leisure industry in many countries. The economic value of recreational and charter fishing sector to regional areas has been recognised as important. The recreational sector, generally catch fish for household consumption or as a hobby, whereas charter fishing has developed into a sport and tourist activity. These businesses may be small and local, or run by national or international companies. The fishing may occur inshore locally or offshore, and may catch species that are also targeted by commercial fishers such as tuna or swordfish (McGoodwin, 1990 pp. 15-16). Conflict between the commercial and recreational fishers over access to fisheries resources continues to be an issue (Cooke and Cowx, 2006).

Global trends in participation rates of marine recreational fishing appear to be growing in most jurisdictions. In 2004 it was estimated that total recreational catch world-wide (marine and freshwater) based on extrapolations from North American statistics, was 47 billion fish of which up to two thirds were released. Although commercial fisheries harvest more fish on a global basis, the recreational catch can contribute to significant catches within a particular fishery. For example, the Atlantic State Marine Fisheries Council reported recreational harvest rates of striped bass, dolphinfish, blue fish, sea bass and tautog off the eastern coast exceeded commercial fisheries catches. In California 16 out of 17 nearshore stocks harvested by recreational fishing exceeded commercial catches (of which two species were recognised as imperilled). There are examples where commercial fisheries have been restricted due to concerns regarding population structure and abundance, and recreational fisheries have then expanded into these areas. In some regions it is difficult to identify whether changes in fish population parameters is a result of exploitation from commercial or recreational fishing sectors (Cooke and Cowx, 2006).

Recreational fisheries also have bycatch issues in that a proportion of fish are released as they are not the intended target, are undesirable, or illegal size, or for game fisheries where catch and release practices are a characteristic of the fishery. The fate of released individuals in terms of stresses from handling and air exposure, physical injury from gear, and post capture mortality can be high. According to Cooke and Cowx (2006) there is evidence that both commercial and recreational fisheries, can cause changes in trophic structure and ecosystem function and damage and degrade habitat. For example, in Florida where 95% of the registered boats are recreational vessels, it was documented that over 6% of seagrass beds were damaged by propellers. Recreational fisheries respond to changes in catch rates by moving location to maintain or increase catches and can operate in areas unprofitable for, or inaccessible to commercial fisheries. Technology developments are increasingly being adopted by recreational fishers providing anglers with the same tools as commercial fisheries. This technology allows recreational fishers to locate fish more rapidly, the increased size and power of vessels increases the range and location of fishing areas; and the use of new materials such as synthetic fibres with increased strength and abrasion resistance result in higher fish landing rates and an ability to catch bigger fish.

Aquaculture

The contribution of aquaculture (inland and marine) to global supplies of fish, crustaceans, molluscs and other aquatic animals has continued to grow from 3.9% of total production by weight in 1970 to 36% in 2006 (which accounted for 47% of the world's fish food supply), with a value of US$7.8 billion. Aquaculture continues to grow more rapidly than all other animal food producing sectors, and has maintained an average annual growth rate of 8.7% world-wide. Annual growth rates of production between 2004 and 2006 were 6.1% in volume and 11% by value. In 2006 countries in the Asia Pacific regions accounted for 89% of production by quantity and 77% of value, of which China produced 67% of the total quantity and 49% by value, of the world total. The remaining production by quantity of 10.5% and 23% by value was from (from highest to lowest) Europe, Latin America and the Caribbean, Africa, North America and the near East. Most aquaculture of fish, crustaceans and molluscs are from inland waters, 61% by quantity and 53% by value; the marine contributes 34% by quantity and 36% by value (most cultured marine species are of high commercial value). Overall global production of the major species groups varies by region. The Asia and Pacific region produces 98% of carp and 95% of oysters (of which China produces 77% of all carp and 82% of oysters) and 80% of shrimps and prawns (with China, Thailand, Viet Nam, Indonesia and India the top five producers). Norway and Chile are the leading producers of cultured salmon accounting for 33% and 31% respectively, with other European producers supplying 19%. In 2006 world aquatic plant production by aquaculture was 15.1 tonnes valued at US$7.2 billion (with average annual growth rates of 8% since 1970 to 2006), and contributing 93% of the world supply. China supplied 72% (valued US$5.2 billion) with the remainder mainly from Asia (Philippines, Indonesia, Republic of Korea, and Japan). Japan is the second most important producer by value (US$1.1 billion) supplying high value Japanese kelp, wakame and nori (FAO 2009 pp. 16-22). There are continued indications that capture fisheries and aquaculture production statistics for China may be too high, as noted in previous issues of the *State of World Fisheries and Aquaculture,* this problem has existed since the early 1990s. Because of the importance of China and the uncertainty about its production statistics, China is generally discussed separately from the rest of the world (FAO, 2009 p.5).

Aquaculture has a long tradition with examples of well integrated aquaculture systems in Asia and the Pacific, where small scale activities were generally limited in impact. With the development of aquaculture as a commercial enterprise aimed at market demands rather than supplying fish for household use, impacts have increased. Commercial aquaculture activities have resulted in the loss of natural environments such as mangroves, salt marshes and mudflats important to wild fish species during their different life history stages, as these are appropriated or converted for fish farming production. Aquaculture requires seed stock for farming and also feed for the farmed species, and both are sourced from wild fish populations. There is also the issue of pollution from aquaculture operations in coastal and nearshore waters. Farmed species are usually exotic to the area and if they escape may compete with local species or introduce disease and pathogens. In some cases chemicals are needed to manage diseases and can result in residues in the final product (FAO, 2007 pp. 76-77). These issues raise concerns regarding sustainability of aquaculture. Frankic and Hershner (2003) suggest that one solution to avoid and lessen some of these environmental issues is the use of polyculture techniques where mix fed species (e.g. finfish, shrimp, herbivorous species and extractive species (filter feeders, shellfish, seaweeds) form a more balanced ecosystem approach to aquaculture (FAO, 2006 pp. 63-64). Genetically Modified Organisms continue to be a controversial issue in aquaculture (FAO, 2009 p. 22). It should be noted that land-based activities can also impact aquaculture operation and contaminate products (FAO, 2006 pp. 63-64).

It is estimated that it takes five kilograms of ocean fish reduced to fishmeal to raise one kilogram of farmed salmon or shrimp. These species of farmed fish are considered two of the most resource intensive methods of food production in the world (WWF/IUCN, 1998 pp. 22-23). Aquaculture uses low cost fish species such as sardines, herrings or anchovies as feed (fishmeal, fish oil, and trash fish) to produce a higher value carnivorous species such as tuna, grouper crabs and shrimps. The two major concerns are; first, that the practice of carnivorous fish aquaculture does not contribute to global fish production as every kilogram of farmed fish requires more than one kilogram of feed fish; and second, converting low value species into high value species can make farmed fish beyond the reach of the poor. Feed accounts for 60-80% of operational costs in intensive aquaculture, and 40-60% in semi intensive aquaculture systems (FAO, 2006 pp. 60-61). Aquaculture has been seen as a solution and an alternative approach to dealing with the problems of wild capture fisheries, in providing fish as food products for humans (WWF/IUCN, 1998 p. 14). According to Liu and Sumaila (2008) it has been suggested that aquaculture production, in particular the carnivorous species, such as shrimp and salmon, cannot continue to grow at the current rate. This is based on a review of salmon aquaculture in four leading countries (Norway, Chile, UK and Canada).

3.3.3 Post harvest sector

The post harvest sector includes processing, distribution, wholesaling and retailing, marketing and consumers. Important aspects of the post harvest sector is reducing waste and post harvest losses; maximising value added fish products through appropriate processing; and developing and improving distribution and marketing systems (Charles, 2001 p. 54). At the micro level local employment, consumer demand and sale of fish for net benefit (price of fish by weight sold less capital investment, annual fixed costs of fishing, and daily running costs) to fishers, companies and communities is important. At the macro level regional and national employment opportunities, market access, increased exports and improved balance of trade are important considerations for nations (Charles, 2001 pp. 54-56).

In the last two decades globalisation has affected the complexity of fisheries and aquaculture sectors by lengthening the chain of interactions as more actors become involved, and the geographical distances between them extend. Diversity and complexity are further reinforced by the dynamics within and between markets, and the wider social, cultural and political environment (Kooiman and Bavinck, 2005 pp. 11-24). At the same time fish processing companies, trade firms and retailers are replacing fishermen as the central agents in the supply chain, with more fish processed into a variety of fish products and delivered to consumers via large supermarket chains. During this same period consumer demand, preferences and product choices have also changed. These changes in processing and provisioning have raised issues regarding food quality and safety (Oosterveer, 2008; Jensen, 2006).

The demand for convenience foods has resulted in the growth of value added fish products In 2004, 59% of the world's fish production for human consumption underwent some form of processing. Unlike other food products, processing does not necessarily increase product final price, as fresh fish often attracts a higher price. Freezing is the main method of processing followed by canning and curing. During the 1990s trade in live and fresh fish products increased, particularly in south-east Asia and the Far East. In developed countries the proportion of frozen fish has also been increasing, and in 2004 accounted for 40% of total production, whereas in developing countries the share of frozen products was 13% as fish in these countries are marketed in live, fresh or chilled form. Apart from some regional differences in Africa (17%) and Asia (11%) cured fish is higher (FAO, 2007 pp. 34-36).

Although global per captia food consumption has been improving there are still regional disparities, particularly in the Asia and Pacific and the sub-Saharan Africa countries. Fish consumption is distributed unevenly between regions and within countries. Consumption of fish products from aquaculture have increased, in 2004 providing 43% of the total fish available for human consumption. Aquaculture, from low value fresh water species has contributed to food security in some developing countries such as Asia. There are differences in consumption pattern by species, demersal fish are preferred in northern Europe and North America; cephalopods are consumed in several Mediterranean and Asian countries; with the consumption of crustaceans concentrated in affluent economies. In developing countries changes in dietary habits include a higher consumption of fish products this has been due in some cases to rapid urbanisation and food distribution, for example through supermarkets. In Asia and Latin America the expansion of supermarkets targets all income groups. Dietary habits have also changed in developed countries, as fish has been promoted as a healthy and nutritious food choice. The demand for fresh fish products has been made possible by improved packaging, reduced air freight, efficient and reliable transport, with food retail chains taking an increasing share of the fresh seafood sector (FAO, 2007 pp. 36-41).

The role of fisheries trade varies among countries, but is important for many economies, and is a significant source of foreign currency earnings for developing countries. There have been changes in geographical patterns of fishery trade. The share of global fishery exports from developing countries has increased from 37% in 1976 to 48% in 2004, with Asian countries accounting for most of this growth. In many countries there is a two way trade in fishery products. The Latin America and Caribbean and Asia and Oceania regions have positive net export positions; Africa has been a net exporter since 1985; Europe, Japan, and North America are characterised by a fishery trade deficit. Shrimp continues to be the most important traded commodity in value terms, followed by groundfish, tuna and salmon. The relaxing of European Union (EU) restrictions on imports of Chinese farmed shrimp has resulted in China becoming the leading supplier of shrimp in Spain. The relative importance of salmon as a traded item has grown recently as a result of the successful salmon farming industry in Chile and Norway, however the unit value of exports has declined during the last 15 years with the growth of industrial salmon aquaculture, but profits have been maintained due to demand and reduced production costs, and economies of scale. Japan is the top world market for sashimi grade tuna. The concentration of worlds' tuna industry in fewer hands is a continuing trend (FAO, 2007 pp. 44-45).

3.4 Social dimensions

The social benefits of fishing include food and other harvestable marine products for production of goods and services for human consumption; employment and support ofcoastal fishing communities; recreation opportunities; and the continuation of indigenous cultural traditions (Kaiser et al., 2005 pp. 497-498). Ecosystem services are supplied at various spatial and temporal scales, and analysis of the scales at which ecosystem services are generated, used and the associated values is important in order to reveal the interests of the different stakeholders in ecosystem management. The formulation of management plans that are acceptable to all stakeholders requires the consideration of these different interests. It might also provide insight into the appropriate institutional scales of decision-making for ecosystem management. For example if an optimal management strategy is sought on the basis of the interests at a particular scale it may lead to unacceptable outcomes for stakeholders at other scales (Hein et al., 2006). The wellbeing of ecosystems and the economic viability of fisheries it supports are important to the wellbeing of fishers and fishing communities. Over-fishing and ecosystem degradation can result in a decrease of food from the sea; economic loss, hardship to fishers, and the livelihood of fishing communities; disrupt traditional cultural practices; and may change cultural diversity (FAO, 2005 pp. 3-6). Consumers, fishers and post harvest workers belong to households and communities, which are considered important social dimensions in their own right (Charles, 2001 pp. 44-45).

Although the social dimension is considered important its analytical and theoretical underpinnings are less developed. Contributing factors may be due to there being no commonly accepted definition for the social, or consensus on what is to be understood by the social. The social dimension is multi-faceted, it refers to both the individual and the collective levels; perceptions and interpretation of social conditions change the behaviour of individuals and social collectives; and the social phenomena cannot be addressed or analysed using the same tools as those used for the environmental and economic dimensions (Lehtonen, 2004). In developing countries the social issues relate to fisheries development, food security, employment, fair trade and the protection of individual and community fishing rights. According to Symes and Phillipson (2009) in many of the developed countries such as Europe and North America the social aspects have often been subsumed under goals for economic growth, or environmental sustainability priorities. To date less attention has been given to the socio-economic factors compared to the environmental and technical aspects of the marine capture fisheries sector.

The social dimensions include people, employment, livelihoods, culture and social benefits; and the social drivers. The social dimensions of fisheries, as outlined in table 3.4.1 below, provides a framework for understanding and describing the social dimensions, components, characteristics and social drivers. The social dynamics operate more at local spatial and temporal scales, although these also influence regional dynamics and collectively are important at the national level. Many of these aspects have been discussed in detail by Charles (2001); Davis et al. (1993); Schirmer (2005); and Jentoft (2000).

Table 3.4.1: A framework for identifying and describing fisheries social dimensions, components, characteristics and drivers.

Dimension	Components	Characteristics	Social drivers
People	Individual	Human capital	Ethics
	Households	Social capital	Equity
	Communities	Community structure and organisation	Values
	Nations		
		Gender	Population growth
		Knowledge	Demographics
Employment	Fishery jobs	Small scale fisheries	
	Fishers	Large scale fisheries	Politics and political will
	Process workers	Dependency on fishing	Power and interest groups
	Infrastructure and support	Alternative employment options	Social objectives
		Working conditions	Collective decision-making
Livelihoods	Income levels	Poverty alleviation	
		Differentials and distribution	
Culture	Indigenous	Cultural traditions	
	Lifestyle	Choices	
		Self determination	
Benefits	Human wellbeing	Food security	
	Equitable sharing	Food safety	

People, communities, social capital and knowledge

Over-fishing is often seen as an example of market failure or a common resource pool issue which, as outlined by Hardin (1968), can lead to “the tragedy of the commons”. As argued by Jentoft (2000), alternatively it may be a sign of community failure, and that viable fish stocks require viable fisheries communities; and therefore well functioning communities are an important contribution to fisheries management. Fishers that live in local communities are enmeshed in cultural and social systems and their fishing practices are guided by values, norms and knowledge which is shared within the community. Where communities disintegrate socially and morally, over-fishing may occur when the norms and community solidarity have been eroded. The ability to communicate and co-operate is lost, and the capacity for collective action also becomes weakened. A number of aspects are changing the social relations among fishermen, these include globalisation and management systems that are based on purchasing and selling quotas allotted to individual fishermen, not groups of fishermen, and rarely to communities.

Fisheries communities do not, however, always fulfil the criteria of a social group possessing shared beliefs, a stable membership, and the expectation of continuing patterns of interaction and relationships. Some communities are characterised by social conflicts, inequities and power differentials and failure to attend to these differences within communities can affect resource management outcomes. So while communities can provide significant inputs that could improve efficiency and legitimacy of fisheries management, they also add complexity and risk. It should be noted, however that communities are not always ready, competent or willing to take on responsibilities, but opportunities for capability and capacity building can over-come these barriers. Co-operative links between communities that address their interdependencies and pool their resources could be established (Jentoft, 2000; Degnobol et al., 2006). Understanding the people who engage in fishing activities, including their motivations, culture and heritage, and their social and economic situations should result in improved communication and co-operation between stakeholders, managers and government. Failures in communication have often led to adversarial relations and tensions between various stakeholders and fishing communities (Kaplan and McCay, 2004).

Social capital and social networks are increasingly viewed as key components in ensuring desirable social and economic outcomes (Grafton, 2005). The notion of capital is usually understood as it relates to natural resources such as stocks of fish, or economic capital invested in an industry for example fishing boats and infrastructure. Social capital generally refers to the networks of social relations characterised by norms of trust and reciprocity that can improve the efficiency of society by facilitating co-ordinated actions. Social capital has often been used to explain differentials in economic development between societies with different levels of social integration. Information sharing, co-ordination of activities, and collective decision-making are often mentioned as benefits of social capital (Lehtonen, 2004 p. 204).

This notion of social capital can also be applied to fishing communities, which over time have developed valuable social capital assets. Social capital includes the interactive networks of relationships that occur within and between communities, which may be based on natural resource extraction. Cultural capital is based on the behaviours, values, knowledge and culturally transmitted ideas of a population, applied to the transformation and utilisation of natural resources (in this case fish). Human capital in the form of knowledge and skills can be acquired from formal and informal education, and associated with the occupational roles of natural resource extraction (Sutinen et al., 2005 p. 46). Social networks represent causal factors and can be divided into three categories: bonding (linkages or strong ties within groups of like minded individuals such as families and fishing communities, which are associated with trust and co-operation and encourage individual fishers to observe rules and sustainable fishing practices); bridging (concerns and linkages across similar but different groups or social networks, that can be important for the diffusion of knowledge and innovation and generating co-operation across fishing communities); and linking (refers to connections across disparate groups or networks at different hierarchies, which are required if the management of fisheries are to be effectively shared between fishers and regulators). Successful fisheries outcomes require explicit consideration of social capital and social networks (Grafton, 2005).

Social incentives relate to group behaviour, and group interactions occur and form the context for individual decisions. Understanding social incentives (moral community structures, ethics, social relations, peer pressure, social preferences, traditional value systems, established rules, social recognition, trust among stakeholders and common interests) in place, is therefore important in understanding how individuals and communities make choices (De Young et al., 2008 pp. 105-106). Individuals are part of communities, and these in turn are situated within nations, which are part of the global economic and social system at different levels and scales. Social behaviour is often viewed in the light of self interest. However, if society understands the need to maintain the productivity of the natural environment then society can, or may choose to, take a broader and longer term perspective. Under these conditions users add responsibilities to rights once they organise around the collective need to maintain resources. Communities develop formal and informal rules for natural resource use, as well as social values and norms (Hanna and Jentoft, 1996 pp. 37-40).

Social views on human relationships towards natural resources and ecosystems, and dependence upon the natural environment can change from one of use and control, to one of stewardship. There are three important criteria for good stewardship. First, the limits of the natural environment must be recognised, and this may require restraint in the short-term to ensure long-term gains and benefits (the precautionary approach).

Second, it is considered more likely to succeed at the local level (community) as there is the benefit of local knowledge, and the consequences are more noticeable and immediate at this level. However, this may not always be possible given the nature of industrial fishing fleets, and globalisation of trade. Third, decisions need to be made over the long-term, based more broadly on wider social, as well as economic values for the long-term benefit of current and future generations of users (Roach, 2000 pp. 67-80).

An important characteristic of fishers is their knowledge of the local marine environment in which they fish. A key element of the EBFM approach requires that all forms of relevant knowledge and information should be included in decision-making. A fishers' knowledge base is not just traditional (developed over time) but also includes recent information based on observations and changes in the marine environment. Both these forms of knowledge are complementary and add more to "conventional" scientific knowledge. This breadth of knowledge is required by governance and management institutions, for understanding ecosystems and human systems, and for fisheries policy development and operational management (Charles, 2001 pp. 328-332).

Employment and livelihoods

Fisheries and aquaculture directly or indirectly play an important role in livelihood and in 2006 an estimated 43.5 million were directly (full and part time) engaged in production, with a further 4 million on an occasional basis (FAO, 2009 p. 6). During the last 30 years the number of fishers and aquaculturalists has grown faster than for those employed in agriculture. In 2004 it was estimated that 41 million people worked (full time or part time) as fishers and fish farmers, representing a 35% increase from 2.3% in 1990, with most from developing countries, principally Asia. China was the highest (with 13 million people) representing 31% of the world total, followed by Africa, North and Central America, South America, Europe and Oceania. The number of employed fishers and aquaculturalists has increased in low to middle income countries but has remained stationary or declined in industrialised countries (estimated at one million fishers), representing a decline of 18% compared with 1990 figures. Factors include investment in more sophisticated technology on fishing vessels resulting in higher efficiencies resulting in fewer fishers employed at sea. The average age of fishers is also increasing as younger workers prefer other career options, because of the part time or seasonal nature of the work and salaries, as compared to land-based opportunities. As a result, many industrialised countries are employing workers from developing countries (FAO, 2007 pp. 22-25).

Artisanal fisheries are estimated to account for 40% of world fish production. In the developed world artisanal fisheries may be important for maintaining small communities at the local level where alternative employment opportunities are limited. In developing countries these fisheries are small-scale involving households rather than commercial organisations, and have an important role in sustaining the livelihoods and food security for large numbers of people (Whitmarsh et al., 2003). Between 1970 and 1996 employment in fisheries in developing countries doubled. In 1998 artisanal and small-scale fisheries contributed 25% of the world catch and accounted for half of the fish used for human consumption. Bangladesh, China, India, Indonesia, Philippines, Viet Nam, have the largest number of fishers in the world. The small-scale sub-sector targets fish, for the international market, which contributes to foreign exchange earnings and in many developing countries revenue from these fisheries, is higher than from agriculture. These fisheries have been important in employment creation, income generation and poverty alleviation, but the per capita share of marine production, per fisher are low because of the large fisher populations (Mathew, 2003 pp. 50-51).

In both developed and developing countries, fishing contributes to local and national economies, as well as supplying a protein rich food. Fishing provides direct employment for fishers and supports many other fishery related jobs such as processing, vessel and gear supply and maintenance, and these have a multiplier effect in terms of other goods and services generated by the fishing industry within a fishing community, at the local and regional level. Some communities have a high dependency on fishing and fishing related jobs for income. Fishing may also provide a high level of job satisfaction and strong community attachment (Charles, 2001 pp. 253-254). The livelihoods approach grew from the recognition of the need to place fisheries in a larger context of households, communities and socio-economic environments. Employment impacts in fishery dependent regions are driven by characteristics of the labour force. In some regions there are few alternative employment opportunities and in communities where fishing has provided traditional employment opportunities there may be an unwillingness to move elsewhere, or find alternative work. Introducing or finding alternative livelihoods is likely to be a challenge (De Young et al., 2008 pp. 7, 37-38).

Culture and self determination

Whenever people share a common means of making a living, following traditional beliefs, are centred around a community or inhabit a region comprising similar communities, and live in the same communities in which their families and other related kin live and work, they are also likely to share a common and distinct culture (McGoodwin, 1990 p. 22). The sustainability and maintenance of cultural diversity and communities are considered valuable social assets in their own right. The practice of fishers in a particular fishery may be based on traditions, beliefs, resource knowledge and skills that have been passed from generation to generation, including knowledge of the environment and a detailed understanding of resource use and sustainability (De Young et al., 2008 pp. 42-43). Access to and use of natural resources as part of cultural traditions and heritage, and self determination are important. Aboriginal peoples pursue these entitlements as the legal and institutional means whereby they can affirm identity, establish political and legal status, and achieve agency in relations with the nation state and non-aboriginal peoples (Davis and Jentoft, 2001). International recognition of customary law and land and fishing rights is emerging as a basis of indigenous peoples, efforts to safeguard their traditional way of life and connection to particular localities and landscapes. Cultural identity is derived from the tribe or local community through cultural forces. There is also a growing awareness of common interests and experience among indigenous communities world-wide, and this sense of identity distinguishes aboriginal people from the western (developed) world view (Groenfeldt, 2003).

Social values and beliefs play an important role in how natural resources are valued, and this in turn influences choices and decisions with regard to governance and management of natural resource use, such as fisheries. The wider social implications include access to marine resources and the equitable sharing of the accrued benefits. The ways humans organise their relationships with each other and the environment differ widely, and particularly with regard to the notion of property. For traditional cultures and groups, humans are embedded in nature and ownership means social obligations, sharing and reciprocity. As economies develop this perspective of human dependency on nature changes to one of ownership and control, and ecosystem goods and services are viewed as resources for production. Ecosystem use is therefore influenced by conditions of economics, culture and politics (Hanna and Jentoft, 1996 pp. 35-38).

Food security and product quality and safety

Oceans play a significant role in meeting basic human needs. For example, the provision of safe and affordable seafood, a livelihood derived from fishing, self determination and choice as it relates to access to fishing resources, and sharing the social benefits that accrue from fishery resources. The role of fish as a valuable food source varies between nations, as do income and the ability to buy fisheries products. This food source is particularly important to countries that lack alternative protein sources, and are crucial to some densely populated countries, where protein intake is low, such as small developing nations. The fishery sector has an important role in poverty alleviation in terms of foreign exchange and food security (FAO, 2005). There are two ways that fishing can contribute to food security directly through the supply of fish as food, and indirectly through wages from fishing or other activities, which can be used to purchase food (De Young et al., 2008 pp. 41-42).

Globally fish provide 16% of animal protein in human diets, but are more important as a protein source for those in developing countries (up to 22%) compared to developed countries (7%). Therefore, geographic variation in fishery dependence for food security and employment has equity implications. Trends in commercial fishing and the development of aquaculture in some coastal areas may restrict access to traditional fishing grounds. This may result in small-scale artisanal fisheries suffering loss of employment and markets. As fish prices rise and more fish are sold on international markets less is consumed locally. These conditions particularly affect the poor in developing countries (Hanna, 1999).

Fish product quality and food safety are important to consumers, and for maintaining export markets. Consumer demand and preferences can vary between harvested fish species, and more recently there has been an interest in seafood products harvested on a sustainable basis. Eco-labelling schemes provide producers with an incentive through market share to manage fisheries on a sustainable basis, and provide customers with information enabling them to choose fish products that are produced on a sustainable basis, for example tinned tuna labelled dolphin-safe (Charles, 2001 pp. 60-61). Although consumers have benefited from the expanded trade in fish products, food safety and quality issues have become important in international trade. Food safety issues in seafood include contamination with pathogenic bacteria, viruses, toxins, and chemicals. Awareness of the importance of responsibility for safety and quality of fish products, over the entire supply chain, has resulted in the need for the development and implementation of international and national standards (Ababouch, 2006; Jensen, 2006). Within the WTO framework health concerns are formalised under two agreements: the 1995 Sanitary and Phytosanitary (SPS) agreement, which is supported by the work of the Codex Alimentarius Commission, and the 1979 Technical Barrier to Trade agreement (Oosterveer, 2008). As early as 1980 many countries reviewed and reformed fish inspection systems, from end product sampling and inspection to preventative Hazard Analysis and Critical Control Point (HACCP) based safety and quality systems. Traceability is more likely for branded products where firms have incentives to take measures to prevent loss of reputation through recall or product failure (Jensen 2006). About 38% of world fisheries production which enters the international trade originates in developing countries, where it is difficult to maintain control over food processing and distribution systems. Although most developing countries have some level of national safety systems, food safety has not been a focal point, as efforts for capacity building have mainly focused on the export sector (Roth and Rosenthal, 2006; Ababouch, 2006).

3.5 Environmental, economic and social dynamics

Traditional governance and management viewed ecosystems and fisheries as static, predictable and tending towards equilibrium states. As outlined by Gaichas (2008) and Mahon et al. (2008), and discussed in this Chapter, ecosystems and human systems are dynamic and complex systems. Mahon et al. (2008) argue that fisheries system complexity and unpredictability are not new, however the approach to uncertainty and risk has been more focused on understanding their sources rather than adapting to them. Ecosystems and humans systems appear to exhibit the characteristics of complex adaptive systems, and an alternate approach is to focus on resilience and adaptation.

3.5.1 The environmental, economic and social context

The environmental, economic and social dimensions set the context for governance and management, as it is within these dimensions that interactions and cumulative impacts occur. Understanding these dimensions is necessary so that governance arrangements and management actions can be developed and adopted, to mitigate and manage human activities, which may affect marine biodiversity and ecosystems. It is equally important to understand economic and social dimensions so that any proposed governance and management actions, while dealing with a particular issue, do not cause other problems elsewhere in the system. This understanding is important if the goals of EBFM are to be met.

Humans and society depend on natural systems for a wide range of services. The vulnerability of marine ecosystems and the value of the ecosystems services provided require different approaches in understanding and management of human activities (Levin and Lubchenco, 2008). When considering the sustainability and resilience of oceans and fishery resources it is important to understand that these resources are subject to natural variability and need to be managed within their biological constraints. Maintenance of healthy populations of wild living resources in perpetuity is inconsistent with unlimited growth and human consumption of, and demand for, those resources (Mangel et al., 1996). It is, however, also important to acknowledge the importance of human needs and the capacity of the natural world to meet those needs (Christensen et al., 1996). The FAO (2003) suggest that the ability to predict ecosystem behaviour is limited and if ecosystem thresholds and limits are exceeded it may result in ecosystem changes or regime shifts. According to the Ecosystem Principles Advisory Panel (1999) these changes may be irreversible, and therefore should be avoided in order to maintain biodiversity and resilience at the species and community levels. Charles (2001) also highlighted the importance of the sustainability and resilience of human systems and the diversity of economic opportunities for individuals and communities.

Sustainability

Ecosystems and human system components are subject to change. Ecosystems may change due to natural variability or due to the impacts of human activities upon them. As humans rely on ecosystems any changes in these will have an impact on human systems. Costanza and Patten (1995) determine a sustainable system as one which survives and persists. From this they ask three important questions:

1. What system or subsystems or characteristics of systems persist?
2. For how long?
3. When do we assess whether the system or subsystem, or characteristic has persisted? (Costanza and Patten, 1995 p. 196).

Human systems are organised around ecosystems in terms of their use and benefit to humans. A question for society and decision makers is which system, subsystems, or characteristics they wish to see persist; over what time frame; and how will these be assessed? These, are new types of questions to be answered by society. What needs to be borne in mind when considering such questions is there are often systems or subsystems of ecosystems that in themselves may not be of interest, but are fundamental to those aspects of ecosystems, which are of interest.

Sustainability is a key element of EBFM, as Charles (2001) points out the concept has broadened from primarily being used in relation to the use of natural resources (ecological sustainability) to also encompass the notion of socio-economic, community and institutional sustainability. Just what is meant by sustainability for each of these components will be context dependent and needs to be clearly articulated. Overall sustainability requires simultaneous achievement of all four components. If all the components are viewed as critical to sustainability then each must be considered. However, developing a comprehensive framework that is able to do this will be a challenge. Some of these sustainability (ecosystems and human systems) considerations as related to fisheries are outlined below:

Ecosystems:

- ecological sustainability includes ensuring the sustainable harvesting of fish stocks;
- maintaining the resource base and related species at levels that do not foreclose future options; and
- the task of maintaining or enhancing the resilience and health of ecosystems.

Human systems:

- socio-economic sustainability focuses on the macro level in terms of long-term socio-economic welfare; generation of and equitable distribution of sustainable net benefits; and ongoing viability of the fishery sectors;
- community sustainability emphasises the micro level in terms of sustaining communities as valuable entities in their own right; enhancing long-term community and group welfare, and their economic and socio-cultural wellbeing; and
- institutional sustainability involves maintaining long-term financial, administrative and organisational capability of fisheries governance and management organisations, that formally or informally have the ability to enforce resource use regulations and management arrangements (Charles, 2001 pp. 188-189).

In an effort to move towards sustainability it has become increasingly important to develop new conceptual frameworks to understand the dynamics of social and ecological systems. Complex system theory investigates how human societies deal with change in linked social and ecological systems, build capacity to adapt to change, and respond to change in a manner that does not foreclose future options (Berkes et al. 2003; Folke et al., 2003).

Sustainability should be pursued in conjunction with, or incorporated with, the fundamental goal of resilience, defined by Charles (2001) as the ability of the natural environment to absorb and bounce back from perturbations caused by natural or human actions. Resilience is considered a key concept for both ecosystems and human systems (Charles, 2001 p. 187). The complex dynamics of ecosystem and human system relationships, structures and processes operate at a range of interdependent nested spatial and temporal scales (Holling et al., 2002).

All dynamic systems including ecosystems and human systems have many feedback loops and nonlinear relationships within and between the dimensions. These interactions can result in periods of relative stasis, punctuated by rapid shifts to new conditions or regimes when systems are overwhelmed by disturbance (Mayer, 2008).

Resilience

The concept of resilience in ecological systems was introduced by Holling in 1973, since then further work has been undertaken including examining approaches to build social and ecological resilience that enhance the capacity of humans systems to deal with complexity and change (Walker et al., 2006 p. 1; Berkes et al., 2003 p. xi). Gunderson (2000) provides a review of the concepts and multiple meanings of resilience; how resilience is related to other key ecosystem properties; and why ecological resilience is key to management of complex human and environmental systems. Gunderson notes some authors define ecosystem as having the quality of a single equilibrium state in which the measure of resilience is in terms of how far the ecosystem has moved from its equilibrium state and how quickly it returns after perturbations. An alternative approach suggests that ecosystems have more than one stable state, where resilience is measured by the magnitude of disturbance which can be absorbed before the system undergoes a regime shift, or significant deterioration (Gunderson, 2000 pp. 426-428). Examples of such regime shifts include transitions from kelp forest dominated ecosystems to urchin barrens (Tegner and Dayton, 2000); and from coral reef to algae dominated ecosystems (Nystrom and Folke, 2001); deterioration of ecosystems such as Chesapeake Bay, that make it more susceptible to, and slower to recovery from disturbances (Boesch, 2000).

The goals of ecosystem management are often stated in terms of maintaining ecosystem resilience, integrity or health and the conservation of biodiversity and community structure and function, but there is no agreed definition of these terms. It is however important to understand what is meant by these terms and define them, so that management objectives can be clearly stated, and effective management measures and actions can be implemented, to successfully meet the stated objectives. Link (2000 pp. 1-6) argues ecosystem health is a misnomer, as ecosystems can exhibit multiple states that are functional, although from a human viewpoint some states are more desirable than others, and suggests ecosystem condition or status is a better term. He considers ecosystem integrity a subjective term, because a key question is, how would such integrity be measured, reproduced or evaluated. Instead Link (2000) proposes the term ecosystem sustainability which refers to the maintenance of specified processes humans would like to see persist in a system, as these could be measurable over time, thereby ascertaining the sustainability of an ecosystem. Costanza and Mageau (1999 p. 105) support this view and propose a healthy ecosystem is one which is sustainable in that it has the ability to maintain its structure and function over time in the face of external stressors.

Notwithstanding these points, resilience remains a key concept to be considered because humans do wish to continue to benefit from ecosystem goods and services. Human activities may compromise ecosystem resilience and in some cases result in regime shifts. There are many examples of such transitions, which suggest that human activities may change the resilience of ecosystems. There are other examples where the management goal, for example to stabilise food production (fish) was successfully achieved (ecosystem engineering) by reducing natural variability of critical structuring variables (fish populations), resulting in an ecosystem wich is more spatially uniform, less functionally diverse, less resilient and more sensitive to disturbances that might otherwise have been absorbed. Short-term success in optimising production may lead to long-term surprises (Holling and Gunderson, 2002 pp. 60-61). Sustainability and resilience of human systems are equally important. As these systems become less resilient and more vulnerable, changes also occur in the management agencies, associated industries and society. Management, in its drive for efficiency, may become progressively more myopic and rigid, the relevant industries become more dependent and inflexible, and the public loses trust. According to Holling and Gunderson (2002) this seems to define a pathology that typically can lead to a crisis triggered by unexpected and external events. As adaptive capacity is lost, each swing of the cycle demands larger and more expensive solutions from both human systems and ecosystems (Holling and Gunderson, 2002 pp. 60-62).

The notion of resilience is growing in importance as a concept for managing and governing complex linked systems of peoples and nature. Social-Ecological Systems (SESs) are complex, and ideas on resilience are not intended to explain the behaviour of SESs, but provide a framework for systematically thinking about the dynamics and attempts to capture the more general, but not detailed, features of how these systems behave to gain new insights. The SESs framework addresses issues about the dynamics of systems at multiple interacting scales; takes a trans-disciplinary approach which provides a broader understanding than obtained from a single theoretical view; and focuses attention on particular system attributes that play important roles in the dynamics of SESs. Components of adaptive management include developing a model which examines how the system behaves under management interventions, that is used to ask questions about system behaviour rather than predicting policy consequences. These questions are then evaluated or tested over time through management actions. This approach acknowledges the lack of certainty in science and adopts an interactive, adaptive approach to achieving success. Very few attempts of adaptive management have, however been undertaken as it is considered too costly and risky (Anderies et al., 2006 pp. 163-164, 173-174).

Both natural and human systems are complex adaptive systems characterised by multiple possible outcomes and the potential for rapid change at a range of spatial and temporal scales (Levin and Lubchenco, 2008). Defining and understanding systems resilience that focuses on the behaviour of the system as a whole is not easy, as what constitutes a resilient coupled social ecological system is not well understood. Understanding the factors that may have led to the loss of resilience are not straightforward as there are many sources (individual behaviour, ideologies, economic policies, management regimes) which influence outcomes. These may also result in cumulative impacts that act to undermine resilience. More research is required for developing design principles for resilient systems and gaining knowledge of managing for resilience through experimental adaptive management approaches that provide new insights and information (Gibbs, 2009).

Marine policy makers are increasingly being asked to consider the resilience of human communities that rely on coastal and marine ecosystem goods and services and the resilience of natural systems. As Gibbs (2009) argues most communities have had little experience in explicitly managing for resilience; an understanding of the factors that make a natural or social system resilient are limited; and there is a lack of consensus based definitions and performance measures for assessing resilience. It will be necessary to over-come these factors before effective resilience based management can be implemented. The potential confluence of natural events including climate change and impacts of human activities on ecosystems, as well as outcomes from a range of economic and social drivers operating at local, national and global spatial scales, and different temporal scales has led many researchers and policy makers to think in terms of increasing the adaptive capacity and resilience of ecosystems and human systems. A move towards a resilience based framework is a large cultural shift for policy makers more accustomed to managing for optimal, economically efficient outcomes, underpinned by optimisation techniques and models, which do not explicitly address system resilience. Communities are concerned with policy making that explicitly encompasses system wide properties, of which resilience is considered one of the most important.

3.6 A biosocioeconomic subsystems model

Many of the ecosystem, economic and social aspects and issues as examined above reflect the importance of understanding and managing the interactions between ecosystems and human systems. Until recently biologists were more concerned with conservation of species and the health and viability of ecosystems. Economists, in turn, tended to be more interested in natural resources as inputs to economic activity, often ignoring the fundamental aspects of biology. Government policy tended to focus on regulatory approaches (Clark, 1989; Hall, 1995). Although the social dimensions are considered equally important, the analytical and theoretical underpinnings are not well developed (Lehtonen, 2004).

While it is important to understand the dynamic relationships within the individual environmental, economic and social dimensions, it is also important to understand the complex relationships, interdependencies and interlinkages between them. Charles (2001) presents these relationships in terms of bio-economic, socio-economic, and biosocioeconomic models. According to Charles (2001 pp. 246-249) bio-economic models in the fishery system include the biological aspects relating to the fish resource, and the economic elements that shape human behaviour in harvesting fish, and these fall into two classes behavioural and optimisation. The behavioural approach is used to explain and predict fishery and fisher dynamics, and used as a tool to examine development and management scenarios. The optimisation approach is used to determine optimal management or development strategies, given a set of specified objectives.

The socio-economic model includes demographic, socio-cultural, economic and institutional aspects. For example:

- how the demographic aspects of the fishery system, such as participation by age and gender, interact with external influences at the national level;
- it also attempts to assess how the socio-cultural aspects (culture, history, tradition) of society impact on decision-making in the fishery system, and how those outside the fishery have power over internal fishery choices;
- how the local fishery economy interacts with the economic structure and dynamics at the regional and national level;
- how the economic inputs (labour and capital) into the fishery are affected by the broader economic environment; and
- how the institutional aspects in terms of local fishery objectives relate to the broader regional and national policy goals; and how the local institutional structure interacts with institutions, legal arrangements, legislation and policy frameworks at the national and/or sub-national levels (Charles, 2001 p. 67).

A biosocioeconomic model integrates the biological, economic and social structure and dynamics of a fishery system within a systematic framework, and may include the bio-economic components such as fish populations dynamics and the capital dynamics of fishing fleets; the behaviour and dynamics of fishers and fishing communities; together with the range of societal objectives such as conservation, income generation, employment and community stability (Charles, 2001 pp. 247-248).

On the basis of the preceding reviews and discussions presented in this Chapter, the biosocioeconomic ecosystems and human subsystems of the model, have been further developed as presented in Figure 3.6 below. A set of environmental, economic and social descriptive frameworks that underpin the biosocioeconomic dimensions have alse been developed. These provide an understanding of the individual environmental, economic and social dimensions, components, characteristics and key drivers, and a descriptive framework that can be used to develop a profile of a particular fishery at the local level, or fisheries more generally at the national or regional levels. These were presented in tables 3.5.2a, 3.5.2b, 3.5.3 and 3.5.4 above.

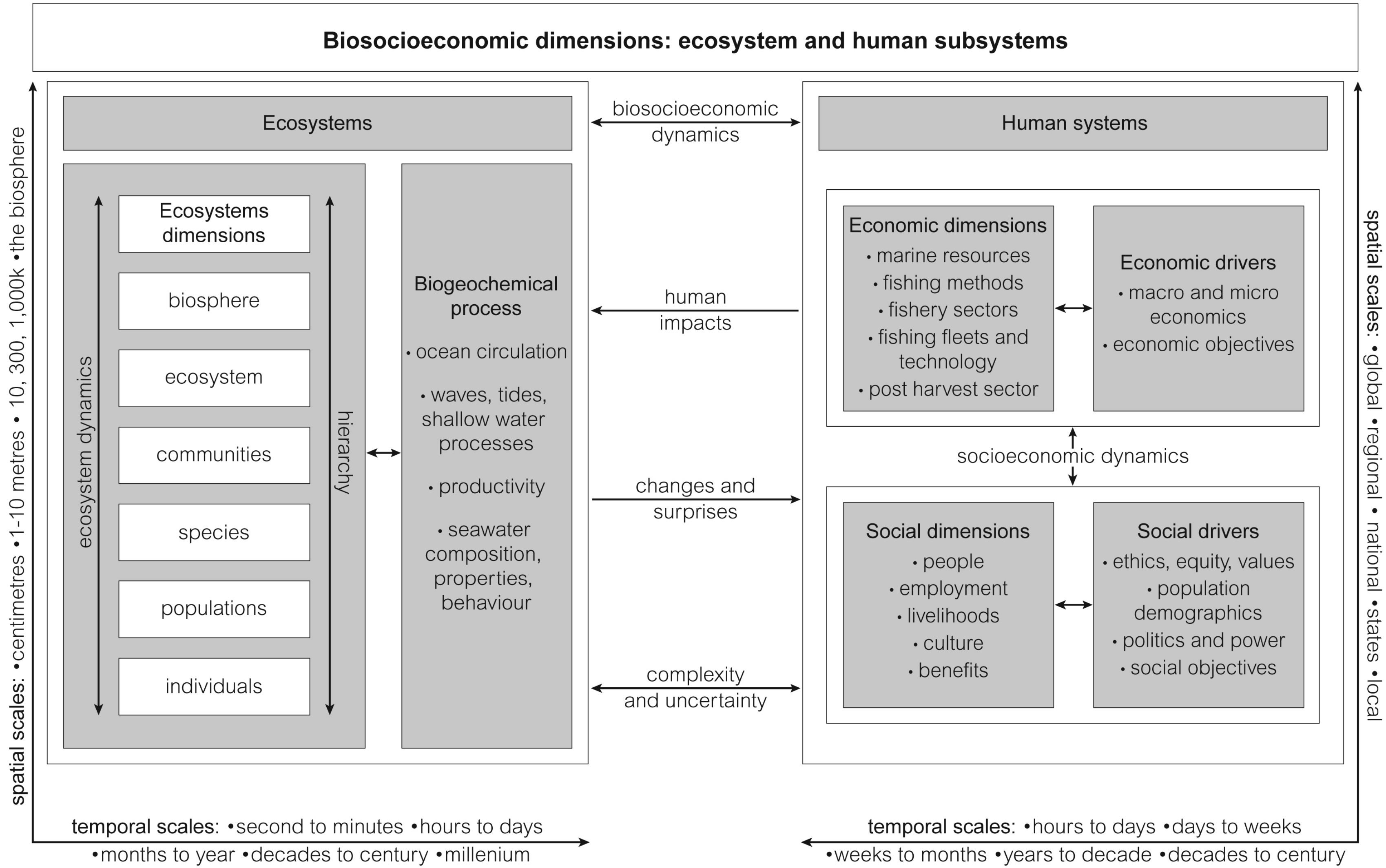


Figure 3.6: A biosocioeconomic systems model: ecosystem and human subsystems.

The model highlights the complexity of the biosocioeconomic dimensions, and the different spatial and temporal scales at which the ecosystems and human systems operate. Uncertainty is a result of the dynamic interactions, both within and between the ecosystems and human subsystems.

3.7 Summary

As the impacts of human activities on the planet increase, it will require a system of governance and management that avoids catastrophic ecosystem changes. Ecosystems provide important goods and services, however ecosystems have thresholds, and continued supply of these benefits requires humans to manage their activities within these limits (Limburg et al., 2002). Human welfare and economic stability are strongly linked to ecological wellbeing, and the major objective of an EBFM approach is to ensure that ecosystem goods and services are not eroded as a result of human activity (Brussard et al., 1998). Marine ecosystems can be impacted by fishing and other marine sector activities. The uptake of sophisticated technology has allowed the development and expansion of fisheries, and as a result there are fewer natural refuges. A sectoral approach to management fails to take into account the cumulative effects of multiple users and uses and their associated impacts.

Many marine fisheries are in decline and the effects of fishing on other ecosystem goods and services are beginning to be understood and recognised. Managing these impacts will require a much broader understanding of ecosystems and human systems than has been encompassed by traditional, single species fishery management (Ecosystem Principles Advisory Panel, 1999). Marine ecosystems are subject to natural variability that can affect productivity and the abundance and natural mortality of fish stocks. Fisheries management needs to recognise this and adjust harvest strategies accordingly. EBFM requires fisheries to take into account the wider ecological aspects of ecosystems. This approach aims to provide a holistic understanding of the ecosystem in terms of an interdependent system with emergent properties of its own (Brunk and Dunham, 2000). Impacts on ecosystems can be due to natural variability or due to anthropogenically induced changes. A major challenge is in differentiating between the two because often natural changes or fluctuations in the environment occur simultaneously with the anthropogenic induced changes (Richardson, 2003 pp. 284-286).

The economic and social dimensions respond to a range of different internal and external drivers, and the dynamic socio-economic relationship may elicit a different response each time. The economic and social system and stakeholders are grouped and organised spatially at the local (individual, household, community), sub-regional, state, national, and global levels. The issues, interests and objectives are likely to be viewed differently by each group of stakeholders at each of these levels. Understanding these views and differences is important in defining the issues and developing proposed solutions. Commercial fisheries supply and demand shortfalls are expected to be filled by aquaculture, but this is not without its own problems. Predicting the future outlook for global fisheries will require details of key parameters of fisheries sectors such as potential harvest; state of stocks; supply and demand; trade; fishing technology; trends and uncertainties; and identifying the main issues and drivers (Garcia and Grainger, 2005).

The purpose of EBFM is to ensure the sustainable harvesting of target fish stock in the long-term, together with a consideration of the wider impacts to ecosystems and other species, and to ensure long-term benefits to fishers and communities are maximised. As the sustainable exploitation of fisheries and other marine resources within an EBFM framework requires an understanding of the ecosystems, consideration of the economic and social dimensions, are equally important, as sustainability depends on understanding how humans and their institutions interact with ecological systems. These dynamic interactions, and wide spectrum of interrelationships and drivers, need to be understood so as to maintain the sustainability and resilience of both ecosystems and human systems.

The biosocioeconomic model as developed in this Chapter provided an understanding of the changing ecosystem and human subsystem dimensions (characteristics processes and drivers) and the dynamic interactions and inherent complexity of the system. The descriptive frameworks provide a means for tracking changes within dimensions over time, and to evaluate the status of each, and trends both positive and negative. This is required for identifying issues and underlying causes, and is particularly important in relation to ecosystems when trying to ascertain whether changes are due to natural variability or impacts from human activities. This information can provide baseline data and the ability to capture important feedback mechanisms between ecosystems and humans systems. For example, how human activities impact ecosystems; how these impacts may result in changes and surprises for human systems; as well as being able to assess the effectiveness of governance arrangements and management measures designed to mitigate impacts and to manage human activities.

According to Costanza et al. (2001) understanding the links between human socio-economic systems, and bio-economic systems and their characteristics could provide guidance for designing sustainable human systems within sustainable ecosystems. The introduction of EBFM has led to new challenges for governance and management. This is the subject of the next Chapter, which discusses governance and management arrangements under EBFM principles.

CHAPTER 4: GOVERNANCE AND INSTITUTIONAL ARRANGEMENTS UNDER EBFM

4.1 Introduction

Governance and management under Ecosystem Based Fisheries Management (EBFM) principles shifts the focus from just target species to broader environmental considerations, as well as the economic and social dimensions. EBFM has also broadened the view and practical operation of governance and management to include both government and non-government institutions and organisations, and the participation of a broader group of stakeholders, both public and private. EBFM has implications for governance and management arrangements at all levels from the international to the local level. The principles and broad objectives outlined in the high level instruments and agreements at the international level have to be incorporated into governance and management arrangements at regional, bilateral, and national levels. Translating these concepts and principles into governance and management arrangements will be complex (Sainsbury et al., 2000).

The Lisbon Principles provide a set of general guidelines for the formulation on how sustainable oceans and fisheries governance might be achieved at various scales of governance from global to local. Sustainable governance includes a core set of guidelines as follows: responsibility, scale matching; precaution; adaptive management; full cost allocation; and participation (Costanza et al. 1999 p. 187). According to Rayner (1999) achieving sustainable governance and management of the oceans and fishery resources requires over-coming two major challenges regarding institutional arrangements. First, managing under uncertainty; and second, the co-ordination across jurisdictions, and between institutions and stakeholders, at the different levels (Rayner 1999). Costnaza et al. (1999) suggest the role of governance and management under EBFM principles is to balance ecosystem needs and human needs that results in sustainable oceans and fisheries conservation, and use. Sustainable governance and management of oceans and fisheries requires a broad trans-disciplinary perspective and an integrated approach. Governance and management are closely interlinked, and within an adaptive system there is opportunity for informed feedback between them.

The purpose of this Chapter is to outline the scope, implications and outcomes for governance and management arrangements under EBFM principles, which have resulted in complex, multi-level and multi-institutional, and stakeholder decision-making arrangements. The multi-level (vertical) and the multi-dimensional (horizontal) cross institutional considerations highlight the issues of institutional interplay and fit. The complexity, uncertainty, risk and consequences require careful consideration in governance and management decision-making. The development of the integrated model is a means of unpacking the governance and management dimensions under EBFM principles.The governance, management and decision-making subsystems (of the integrated systems model as introduced in Chapter 2, and highlighted in Figure 4.1 below), will be further developed.

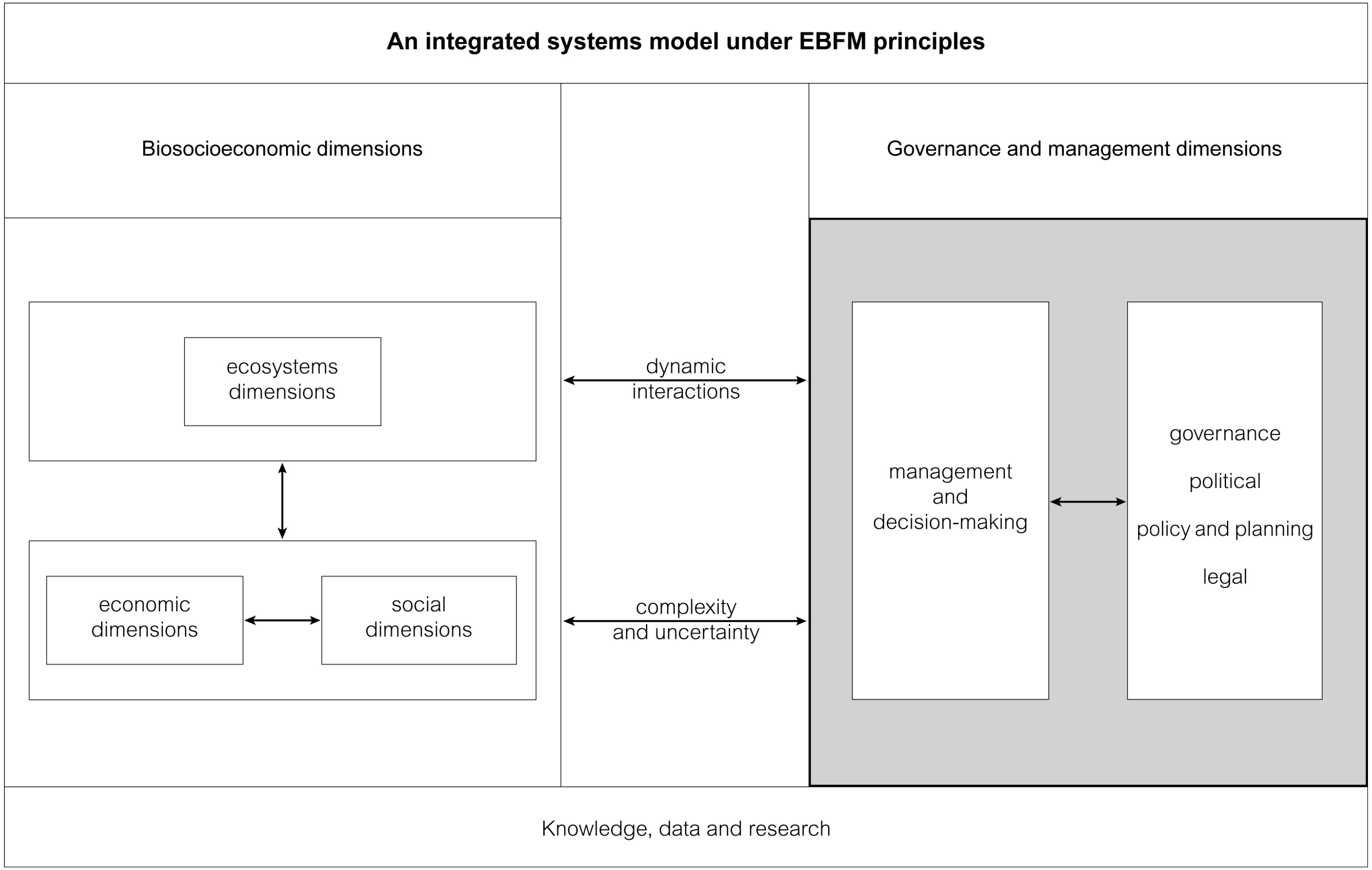


Figure 4.1: An integrated systems model under EBFM principles.

4.2 Governance and management

The literature reveals that there are a number of views regarding the scope of governance and management. Governance is the sum of the legal, social, economic and political arrangements and is a means by which society defines goals and priorities, and advances co-operation and collective decision-making at all jurisdictional levels. It includes both formal and informal institutional arrangements, such as inter-governmental organisations and partnerships between governments, industry and civil society (Scanlon and Burhenne-Guilmin, 2004 pp. 1-2). Governance in its broadest sense includes both state and non-state institutions (Weller, 2000 p. 4). Governance and management form a framework of social and economic systems, and legal and political structures, through which oceans and fisheries are managed (Allison, 2001). An ecosystem approach for responsible fisheries alos requires self governance by politicians, industry, the public, and the scientific community (Sissenwine and Mace, 2003). Global ocean governance is described as a set of ocean rules and practices which are equitable and efficient in resource allocation and use, that provides a collective means of resolving conflicts and dealing with issues (Friedheim, 1999).

Governance and management regimes vary between cultures and in many cases these differences relate to the perceived role of the state. Traditionally the role of governance was viewed as the domain of national governments, often with a top down hierarchical control and command style, with a focus on the processes of politics, policy and planning and regulatory arrangements, with management as a separate function and activity. Concurrently with globalisation and the development of EBFM, this view has broadened conceptually and practically. In response to these changes an alternative approach has emerged, which has been described as interactive governance. This new perspective reflects the growth of social, economic, and political interdependencies; which as a result lengthens the chain of interactions across sectors and organisations at different levels; and increases the number of participating public and private stakeholders with shared interests (Kooiman and Bavinck, 2005 pp. 15-16).

4.2.1 Benchmarking for fisheries governance

Fisheries face major and complex challenges, and Grafton et al. (2008) argue that the key determinants of fisheries sustainability is governance, which is described as the legal, social, economic and political arrangements used to manage fisheries, including incentives that promote marine conservation. This requires more than preventing over-fishing: it involves institutional change which encompass the public good of the oceans (biodiversity, ecosystem integrity, and sustainability); societal values (existence, aesthetic and amenity); and incentive based approaches that provide pathways towards enhanced public and private benefits. As Grafton et al. (2007) note fisheries governance and management involves two key challenges. First, the need to understand the current state of fisheries and the principal feedbacks of fishers and ecosystem dynamics; and second, the capacity to translate this understanding into effective actions, to achieve biological, social and economic goals. Grafton et al. (2007) developed a framework to benchmark fisheries governance, to improve performance and promote resilient ecosystems and profitable fisheries. It is based on three premises: first, resilient marine ecosystems and sustainable fisheries require high order objectives enacted in legislation and acted upon through governance and management strategies. Second, managers must account for uncertainty and effects of management actions, this requires risk assessments which include an analysis of alternative management actions, and risk management that accounts for multiple uncertainties. Third, incentive based approaches such that the fishers, management and social interests coincide, and which discourages unsustainable fishing practices. Five key factors for governance include accountability, transparency, incentives, risk assessment, management and adaptability. As outlined by Grafton et al. (2008) effective governance, also requires the provision of necessary information to assess trade-offs; dealing with use and non-use conflicts; compliance with rules; allocation of the costs among fishers; providing physical, technical and institutional infrastructure; and encouraging adaptation to change to achieve sustainability.

4.2.2 Governance functions and structures: roles and responsibilities

Governance and management have different but complementary respective roles, responsibilities, processes and cycles, which may operate at different spatial and temporal scales. In many western developed countries such as Australia, the scope of governance and management systems includes the political, policy and planning, legal framework, and strategic and operational management. In some ways there is an inferred hierarchical aspect in the sense that each dimension (political, policy and planning, legal and management) successively set parameters for each of the following dimensions. When considering the governance and management dimensions on an individual basis in terms of the structure and function, the political agenda may be set at the national level by government in response to national issues, public concerns, or by societal values and preferred choices. A policy and planning framework translates the political agenda into policy initiatives, and legal instruments are developed and laws enacted to support policy and planning. Collectively these governance arrangements provide parameters for management. Acting within these parameters, management develops strategic plans that provide a focus for operational management at national and local levels (Davis and Keating, 2000; Bridgman and Davis, 1998; Kimball, 2001; Charles, 2001; FAO, 2003).

Marine governance and management dimensions are outlined in tables 4.2.2 a, b, c. These tables provide a framework to distinguish these different roles and responsibilities, together with their respective dimensions; processes and cycles; participatory decision-making; and the key issues and drivers. Understanding these aspects is important for achieving an integrated governance and management approach, and over-coming the issues of horizontal and vertical fit. Aspects of these issues have been discussed by Davis and Keating (2000); Bridgman and Davis (1998); Kimball (2001); Charles (2001); FAO (2003) and are presented in the tables 4.2.2 below.

Table 4.2.2a: The political role and responsbilities

Dimensions	Processes and cycles	Participatory decision-making participants/stakeholders	Key issues/drivers
Power Influence Legitimacy Ethics, Worldviews, perception Assumptions Choosing policy	Beginning of term: election of government and period of development Middle term implementing government mandate and governing End of term run up to election Electoral cycle usually 3-4yrs	National and State Governments: Cabinet Ministers Political parties and organisations Voters Trade Unions Media Working and focus groups Expert and advisory groups	Equitable distribution and sharing of benefits within and between nations and future generations Societal choice different views, values, interests Political will Pressure from interest groups Complexity issues Longterm responses vs short term political gains Intergovernmental relations

The the political agenda, may be a proactive or reactive response to national issues and to international and regional instruments and agreements that the nation is party to.

Table 4.2.2b: The policy and planning role and responsbilities

Dimensions	Processes and cycles	Decision-making participants/stakeholders	Key issues/drivers
Equity Accountability Efficiency Effectiveness	Process National policy cycle: Identify issues Policy analysis Policy instruments Consultation Coordination Decision-making Implementation Evaluation Cycle Usually 1-3 years and linked to electoral cycles, but may be shorter or longer timeframe	Executive government Public servants Government departments and agencies Sectors bodies Industry NGOs Public Media Consultation forums	Identifying the issues and defining the problem from the rhetoric, agendas, and drivers Balancing the different and competing interests Agreement on, and setting of policy objectives Developing appropriate and effective policies Choosing suitable policy instruments in response to the issue and advising government Coordination/consistency/ integration across environmental, economic, social policies and initiatives Implementation: conditions and pitfalls, strategies Political constraints – short term planning

The role of policy and planning is to translate the political agenda into a policy and planning framework, through policy development and initiatives, and often require legal actions.

Table 4.2.2c: The legal role and responsbilities

Dimensions	Processes and cycles	Decision-making participants/stakeholders	Key issues/drivers
Develop and enact laws that support policy and planning, adjudicate and rule on cases. Provide parameters (rules and regulations) within which actors (stakeholders) must operate Soft and hard laws Representative Equitable Rules regarding rights and responsibilities Enforceable	Develop proposed law Pass into law Adopted Reviews Time lines set by political and policy and planning components National legal cycles follow national political and policy and planning cycles	Parliament Statutory authorities Judges, Lawyers Courts Tribunals	Ineffective or out of date Acts Legislation Regulations including enforcement, monitoring and use and access rights Some Acts, legislation & regulations are not fully implemented Fragmentation, lack of coordination and harmonisation Falls behind changing circumstances i.e. technology

The legal role is to develop and enact laws that support policy and planning, adjudicate and rule on cases. Provides parameters (rules and regulations) within which actors (stakeholders) must operate.

Table 4.2.2d: The management role and responsibilities

Dimensions	Processes and cycles	Decision-making participants/stakeholders	Key issues/drivers
Management style command, co-management, self management or centralised or decentralised Management approaches LME, ICM, MUM, Co-management, self management Accountability Consistency Performance	Strategic (planning) management identifying issues, planning, developing strategies and initiatives short 1 year, medium 3-5 years, and long term 5 – 10 years Tactical and operational management setting operational objectives management processes, measures, tools, monitoring	National management agencies and institutions Public servants Government departments and agencies Sectors peak bodies Industry NGOs Public Decision-making forums Technical and expert advisory groups	Manage human activities within and between sectors and across jurisdictions Translating high policy statements into management actions, Identifying uncertainties and key risks Developing indicators and reference points Monitoring and evaluation of

Dimensions	Processes and cycles	Decision-making participants/stakeholders	Key issues/drivers
	performance assessment and reporting, review and evaluation decision-making daily, weekly, monthly, quarterly, annually		performance Managing competing interests and conflict resolution Drivers

The management role is to develop strategic plans and operational actions to manage human activities that may impact ecosystems in accordance with the political agenda, policy and policy initiatives, and the legal requirements.

4.3 Governance and management: a multi level framework

An outcome of the development of international instruments and agreements, and the adoption of an EBFM approach has required a redefining and further refinement of the structure and function of governance and management at different spatial scales. Multi-level governance and management is now part of the oceans and fisheries decision-making system. The international component has implications for the nation state in terms of changes to its traditional authority. Nation states maintain authority nationally, but may have to accept compromise within bilateral, regional and global forums, and to collaborate and co-operate with other nations at these different levels. At the national level the participatory decision-making process has been reconstituted and redistributed to include a wider range of stakeholders (Cole, 2003; Paavola, 2007). Some of the key aspects that relate to the multi-level framework relating to governance and management, at the international, regional and national levels will be discussed next.

4.3.1 International

As discussed and outlined in Chapter 2 the EBFM approach has wide support at the international level, as demonstrated by the range of international governance initiatives. International instruments and agreements embody common perceptions of problems and how to deal with them, as well as providing a forum for review. A formal agreement sets down what each nation may expect from another, which is particularly important when coastal or marine resources are shared, and provides a mechanism for minimising conflicts and settling disputes between nations states (Kimball, 2001). In principle these provide a conceptual basis and a set of guiding principles, which may be useful when implementing EBFM. In practice, however, it should be noted that some instruments have been ratified, others have not, and nations may be party to only some of these instruments. So while there has been a response to, and a changing world view towards oceans and fisheries governance and management at the international level, adoption may vary at the regional, bilateral and national levels. The Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) came into force in 1982 and is often referred to as the first example of an international ecosystem approach to fisheries management (outlined in box 4.3.1).

Box 4.3.1: *CCAMLR an example and application of an EBFM approach*.

The approach taken by the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) is often referred to as first example of an international ecosystem approach to fisheries management. The Convention is part of the Antarctic Treaty System and forms the regulatory regime for Southern Ocean Fisheries, of which the two main target species are the toothfish (Patagonian and Antarctic) and krill (Molenaar, 2001). CCAMLR was signed in 1980 and its goals are to enable rational use of marine species and ensure the principles of conservation are met. The Commission comprises 23 members and receives advice from the Scientific Committee, which comprises Fish Stock Assessment (WG-FSA), Ecosystem Monitoring and Management, and Incidental Mortality Arising from Longline Fishing). CCAMLR suffers similar problems of other international conventions where cooperation is required from a large number of members. Between 1987 and 1990 a Working Group on Developing Approaches to Conservation began to interpret the Conventions objectives and to provide mechanisms for decision-making based on an ecosystem approach. It takes a precautionary approach and the development of assessment methods that are better directed for achieving the objectives of the convention; are more able to take uncertainty into account; and more able to achieve consensus on specific catch limits through the application of agreed decision rules. Other measures to ensure sustainability require that the development of any new fishery should not occur faster than the Commission can evaluate its potential consequences, and which the objectives under Article II are met; and catch limits have been set for each bycatch species, in each statistical area, and measures are adopted to prevent local effects of targeting by commercial operations (Constable et al., 2000).

Predictive models are used to determine whether indirect effects of fishing, such as trophic dynamics are being affected, and can also be used for designing monitoring programs that provide feedback on the effects of fishing to signal when changes to harvest strategies may be required. For example, although the Antarctic krill fishery is currently restricted the fishery has the potential for expansion. Under CCAMLR the impact of fishing on dependent species is a major consideration. The CCAMLR Ecosystem Monitoring Program was established in 1989 to detect changes, particularly with respect to krill dependent predators to be able to differentiate between effects due to fishing or natural variability (Reid et al. 2005; Constable et al. 2000). However, as noted by Atkinson et al. (2009), despite research estimates total biomass and annual production of Antarctic krill remains uncertain, and the variable recruitment success of krill leads to large inter-annual fluctuations in abundance, which has implication for further development of the fishery. As Constable et al. (2000) concluded, the krill catch is low compared with the long-term precautionary yield, and further expansion is likely to occur, therefore CCAMLR has yet to face testing of its ecosystem approach. Other challenges for CCAMLR relate to the Patagonian toothfish, which attracts a high market value and is subject to illegal unregulated and unreported (IUU) fishing by vessels which operate under flags of states that are not members to CCAMLR, and therefore not subject to its rules. This is an issue as toothfish are vulnerable to overfishing as they are slow growing and late maturing. CCAMLR imposes mitigation measure to mitigate seabird bycatch, and has been effective at reducing bycatch in its fisheries, however IUU operators do not comply with these measures. This is an issue, particularly for albatross and petrels as they dive for baits during the setting of longlines, and where large numbers are caught by IUU vessels, this is unsustainable for the species and populations concerned (Waugh et al., 2008; Clark and Hemmings, 2001).

The international aspects chosen for discussion in this section include the establishment of the 200 nautical mile Exclusive Economic Zones (EEZs); a brief overview of the development and history of international response to oceans and fisheries issues; and how trade agreements may help support the international conventions, and implementation of EBFM.

Establishment of the 200 nautical mile Exclusive Economic Zones

The establishment of the 200 mile Exclusive Economic Zones (EEZs) has been one of the most important and far reaching changes. Negotiations at the third United Nations Conference on the Law of the Sea (UNCLOS III, between 1974-1982) saw the United Nations Law of the Sea Convention (LOSC) developed. This Convention was negotiated in response to the perception that international efforts to manage human uses of marine resources had not been able to deal with emergent challenges. Prior to LOSC entering into force in 1994, the 200 nautical mile limit came to be widely accepted and became customary law. LOSC established the 200 nautical mile EEZ, which extended national sovereignty from 12 to 200 nautical miles, and stipulated nation states must ensure that the marine living resources within their EEZs were not endangered by over-exploitation, and required regional co-operation and management for highly migratory stocks. The high seas are beyond national jurisdictions and require international co-operation for management. The majority of the oceans, primary productivity and fisheries production is in the coastal shelf region and is now mostly within nation's EEZs. Although the establishments of national EEZs provides a common framework, governance and management arrangements will vary because each nation faces different challenges, (Hoel et al., 2005 pp. 3-9).

Garcia and Hayashi (2000) make an interesting observation regarding the spatial evolution of oceans and fisheries governance from global to local and vice versa. More recently the geopolitical and socio-economic processes and the introduction of EEZs have extended national jurisdictions, at the same time fragmenting the ocean area into smaller geographical units linked to increasingly localised and decentralised governing institutions. Conversely, the introduction of EBFM and concerns relating to the conservation and protection of ecosystems, has led to the aggregation of oceans and fisheries governance and management through Large Marine Ecosystems, or at regional levels between a number of nation states through Regional Fisheries Management Organisations (RFMOs). Interactions between these two processes can cause conflicts. Management along geopolitical lines cannot account properly for the ecosystems spatial interactions and trans-boundary effects; and conversely management on the basis of ecosystem boundaries may not lead to effective decision-making.

International response to changing oceans and fisheries issues

An international regime designed to maintain the sustainable use of living marine resources has emerged in response to the changing oceans and fisheries issues. This provides a framework for resolving oceans and fisheries issues at a range of spatial levels. International instruments and institutional processes both stimulate and provide an organising framework for a wide range of initiatives (Hoel and Kvalvik, 2006). Early agreements targeted conservation of marine living resources and the study of fisheries in the North Atlantic. Other issues included risks posed by international shipping such as the transport of hazardous goods and the discharge of oily wastes. During the 1970s sector agreements related to the offshore oil and gas industry, and dumping of toxic wastes at sea. Agreements for small, semi-enclosed or closed seas covered all sources of marine pollution and land-based sources (Kimball, 2001 pp. 2-4). A broad issue of concern which emerged in the 1980s was that of straddling and highly migratory stocks (stocks that straddle or transcend the boundaries of state EEZs), or are found on the high seas (Hoel et al., 2005 pp. 5-6). LOSC has since been supplemented by the 1995 Agreement on the Conservation and Management of Straddling Fish Stocks and Highly Migratory Species (Fish Stocks Agreement of FSA). The agreement provides governance rules for management to ensure long-term conservation and sustainable use of these species (Kimball, 2001). The Convention on Biological Diversity aims to conserve biological diversity and sustainable use of its components. The high seas represent 50% of the earth's surface, which are outside state EEZs, and are generally an open access resource. During the 1980s and 1990s new areas of concern for oceans were impacts from the oil and gas sector; the future development of biotechnology and deep sea mining sectors; and distant water fishing fleets. These sectors may directly and indirectly impact a range of habitats and biological communities, and threaten biodiversity of the high seas (Kimball, 2001 pp. 2-4). A proposed action to address these issues was to create a system of High Seas Marine Protected Areas (Baker et al. 2001). It should, however, be noted that as it has been difficult to manage these activities within state's EEZs, and thus will require a different international approach, centring on co-operation and compliance to make this feasible.

International environmental and trade agreements

Globalisation has changed fisheries production, trade regulations and interactions at all levels. Changes due to globalisation occurred prior to 1950, but since then the scale of transition to global capitalism, industrial mass capture fishing techniques, production and trade has been of a different and much greater order. By the 1990s a global fisheries crisis was recognised in terms of over-exploited fish stocks and awareness of the links between fishing and its effects on ecosystems, as well as the associated economic and social costs (Chuenpagdee et al., 2005 pp. 27-30). Trade agreements are an important aspect that can support governance and management. The international trade of marine resources from commercial fishing and aquaculture takes many forms in terms of species (animals and plants), through an array of processed products which have different market values. The globalisation of trading markets, together with multi-national trade arrangements has, over time, changed the supply and demand for marine products. Fisheries demand can be seen as influencing future supplies resulting from adjustments caused by management regimes. Sustainable management regimes provide ongoing supplies, but unsustainable regimes are likely to result in supply and demand gaps (Ruckes, 2000 pp. 1-3).

Since 1948 the General Agreement on Tariffs and Trade (GATT) provided the rules for the trading system. The last GATT round was the Uruguay Round (1986-1994) which led to the creation of the World Trade Organisation (WTO) in 1995. International trade (including fish products) among nations is now regulated under the WTO. The GATT still exists as the WTO's umbrella treaty for trade in goods, updated as a result of the Uruguay Round. The WTO has no specific agreement with regards to the environment, but a number of WTO agreements include provisions for dealing with environmental issues. Most of the WTO agreements are the result of the 1986–94 Uruguay Round negotiations, signed at the Marrakesh Ministerial meeting in April 1994 (Potts and Haward, 2007). The WTO Agreement includes direct references to the objectives of sustainable development and the need to preserve the environment. In order to minimise trade disputes the WTO prefers to see trans-boundary or global environmental problems dealt with by co-operative multi-lateral actions, under multi-lateral agreements. These instruments indicate the need for the precautionary management of the marine environment and the preservation of marine biodiversity (Potts and Haward 2007). The agreement establishing the WTO states in the preamble the *Parties* to this Agreement should “recognise that their relations in the field of trade and economic endeavour should be conducted with a view to raising standards of living, ensuring full employment and a large and steadily growing volume of real income and effective demand, and expanding the production of and trade in goods and services, while allowing for the optimal use of the world's resources in accordance with the objective of sustainable development, seeking both to protect and preserve the environment and to enhance the means for doing so in a manner consistent with their respective needs and concerns at different levels of economic development” (World Trade Organisation, 2010).

A WTO work program on trade and the environment resulted in the establishment of the Trade and Environment Committee. Its duties are to study the relationship between trade and the environment, and to make recommendations about any changes that might be needed to trade agreements. The committee’s work is based on two important principles. First, the WTO is only competent to deal with trade. With regard to environmental issues its only task is to study questions that arise when environmental policies have a significant impact on trade. Its members do not want it to intervene in national or international environmental policies or to set environmental standards. It is argued that other agencies that specialise in environmental issues are better qualified to undertake those tasks. Second, if the committee does identify problems, its solutions must continue to uphold the principles of the WTO trading system (World Trade Organization, 2007 p. 65). There are about 200 international agreements (outside the WTO) dealing with various environmental issues currently in force. They are called multi-lateral environmental agreements (MEAs). About 20 of these include provisions that can affect trade, for example they can ban trade in certain products, or allow countries to restrict trade under certain circumstances. Among them is the Convention on International Trade in Endangered Species (CITES) (World Trade Organization, 2007).

International Trade in Endangered Species of Wild Fauna and Flora

Many traded wildlife species are not endangered, but the existence of an agreement to ensure the sustainability of the trade is important in order to safeguard these resources for the future. The trade in wild animals and plants between countries, measures to regulate it, requires international co-operation, to safeguard certain species from over-exploitation. CITES is an international agreement between governments to which states (countries) adhere voluntarily. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival. States that have agreed to be bound by the Convention are known as Parties. It provides a framework to be respected by each Party, which has to adopt its own domestic legislation to ensure that CITES is implemented at the national level (Convention on International Trade in Endangered Species of Wild Fauna and Flora, 2010a).

CITES works by subjecting international trade in specimens of selected species to certain controls. All import, export, re-export, and introduction from the sea, of species covered by the Convention has to be authorised through a licensing system. Each Party to the Convention must designate one or more management authorities in charge of administering that licensing system, and one or more scientific authorities to advise them on the effects of trade on the status of the species. As highlighted by Haward (2004) few marine species are listed under CITES, and those are primarily the higher vertebrates, such as great whales, sea turtles and salt-water crocodiles, with only a limited number of fish species.

The species covered under CITES are listed in three Appendices of the document, according to the degree of protection they need. Appendix I include species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances. Appendix II includes species not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilisation incompatible with their survival. Appendix III contains species that are protected in at least one country, which has asked other CITES Parties for assistance in controlling the trade. A specimen of a CITES listed species may be imported into or exported (or re-exported) from a State which is party to the Convention, only if the appropriate documentation has been obtained and presented for clearance at the port of entry or exit. There is some variation of the requirements from one country to another and it is always necessary to check on the national laws as these may be stricter (Convention on International Trade in Endangered Species of Wild Fauna and Flora, 2010b).

4.3.2 Regional arrangements

At the regional level, there may be environmental issues and impacts that are not contained within EEZs. For example the management of straddling stocks and highly migratory species, as well as illegal, unregulated and unreported (IUU) fishing. These are trans-boundary issues, which require management at the regional level (Sydnes, 2005 p. 117). Regional governance and management responses to international requirements and regional issues have been developed and implemented through a range of institutions and organisations, such as the Regional Seas Programmes (RSP) and the Regional Fisheries Management Organisations (RFMOs). However, a number of weaknesses have been identified. Many states are not party to the instruments and this limits the extent of their application; provisions in some instruments are ambiguous with respect to the protection of the marine environment, and surveillance, enforcement, and monitoring is also a challenge (Aqorau, 2003 p. 38).

An effective response to these issues will require nation states to work co-operatively. This might prove difficult for several reasons. Members may come from diverse cultural backgrounds with different government regimes; face different national challenges; with differing values, interests, priorities, and perceptions on issues and solutions. Nations within the geographic area that have an interest in, and access to shared resources, may be denied membership, or choose not to participate in regional governance and management arrangements and forums, and these difficulties may lead to conflict. Added to these challenges are the issues of equitable sharing of benefits; data collection and management; monitoring and compliance; and effective mechanisms for dealing with non-compliance. Each nation state also has to balance the needs and objectives of the regional group with those of their own nation state (Munro et al., 2004 pp. 95-110; Hoel et al. 2005 p.6). A number of broad issues that may reduce effective regional management include conflicting and/or poorly defined objectives; weak or absent incentives for negotiation; a general absence of agreed allocation formulae; poorly responsive and inflexible management systems and regimes; poorly defined ownership and authority; and different funding and scientific capacity within the membership (Butterworth et al., 2004 p. 348).

Under the United Nations Environment Programme (UNEPs), the Regional Seas Programme was started in 1974 in order to develop a plan of action for the Mediterranean Sea and was adopted in 1975. Since then 13 other regional Action Plans have been established with more than 140 countries participating. Some key issues covered by the Regional Seas agreements include sustainable development; ecosystems and biodiversity; living marine resources; land-based sources of pollution; shipping and sea-based pollution; coastal development; vulnerability of small islands; highly migratory species; and marine mammals. An Action Plan outlines the strategy and substance of the programs, based on the region's particular environmental challenges as well as its socio-economic and political situation, and usually includes an environmental assessment, management and legislation, and financial arrangements (United Nations Environment Programme, 2010a).

In resposne to a request by its Governing Council, UNEP has developed a new global strategic strategy for 2008-2012 as follows, to enhance sustainability and effectiveness of Regional Seas Programmes; implement the Beijing Declaration of the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities; strengthen regional co-operation; contribute to the effective implementation of the 2010 biodiversity targets; emphasise the need to implement the ecosystem approach in Integrated Marine and Coastal Management (ICAM); assess and address the impact of climate change; undertake activities that support the WSSD Plan of Implementation and the Jakarta Mandate; and recognise the need for economic valuation of marine and coastal ecosystem services (United Nations Environment Programme, 2010b).

Regional Fisheries Management Organisations

Regional Fisheries Management Organisations (RFMOs) provide governance for oceans and fisheries at the regional level. There are 30 regional bodies that deal with marine fisheries half were established after 1950 and another fourteen bodies have been established since the 1982 adoption of the United Nations Law of the Sea. Some were set up under the FAO Constitution, others under international agreements between three or more parties. These bodies may be advisory or regulatory; with a diverse range of mandates functions, structure and financial resources; and each has its own particular focus (Swan, 2000).

Lugten (1999) undertook a review of the measures undertaken by RFMOs to address contemporary fishery issues, a summary of key points is provided below. This review indicatd at the time, since the early 1990s, the international community has adopted a number of instruments to enhance and develop the legal framework for fisheries management as laid down in the 1982 United Nations Convention on the Law of the Sea and the Convention on Biological Diversity 1992. These instruments, and others, were designed to deal with fishery issues such as excess fleet capacity; bycatch and discards; environmental degradation of fish habitats; monitoring, control and surveillance (MCS) of fishing vessels; measures to enhance data collection; and application of the precautionary approach. The instruments impose specific duties or responsibilities upon both RFMOs and their respective members. The purpose of the review was to analyse the extent to which the instruments had, or had not been, implemented by, or incorporated into the activities of six FAO, and twenty two, non-FAO RFMOs.

The review indicated that very few bodies had started to implement the conservation and management measures provided for in the post 1982 fishery instruments. The instruments present complex political, managerial and scientific considerations that cannot be resolved quickly. The implementation of these instruments may require amendment of the RFMOs constitutional agreement. In many cases, the original terms of reference or mandates were constructed prior to the 1982 instruments. From information made available to the FAO, only two RFMOs were acting to amend their mandates in order to allow them to implement the above mentioned requirements. Most RFMOs, however, are examining the post 1982 instruments, and considering, through appropriately constituted working groups, the consequences of, and steps necessary for implementation, of these instruments (Lugten 1999). As a result, despite international expectations of RFMOs in taking effective measures to conserve and manage marine resources and capture fisheries, there is little facility for this to occur unless their roles and functions are strengthened. This is important because under existing international law, and within the current framework for the management of straddling stocks, highly migratory species, and high seas fish stocks, RFMOs provide the only realistic mechanism for the enhanced international co-operation for their conservation and management (Lugten, 1999).

A more recent review by Willock and Lack (2006) also highlighted that the broader international expectations placed on RFMOs in the past decade have not been met, and RFMOs have largely failed to meet their own mandates. RFMOs have generally failed to prevent over-exploitation of straddling and highly migratory fish stocks, to rebuild over-exploited stocks and to prevent degradation of the marine ecosystems in which fishing occurs.Some RFMOs are moving to develop management strategies framed within the precautionary approach and an ecosystem approach to management, there is also evidence of some taking a best practice approach particularly with regard to compliance and enforcement; trade related measures; and initiating a formal review process. Despite some improvements, what remains as a challenge is identifying practical ways in which RFMOs more generally might address current deficiencies, and the need for action is immediate.

These issues can be illustrated by examining performance of RFMOs responsible for the management of tuna stocks. As outlined by Hunt (2006) the Southern Bluefin Tuna fishery is characterised by globalisation, increasing trade and capital flows, and improved technology. In 1989 SBT quotas were introduced for the catches of Australian, New Zealand and Japanese fisheries. The Commission for the Conservation of Southern Bluefin Tuna (CCSBT) was established in 1994 and is responsible for managing SBT stocks. Initially catch quotas did not apply to non-member countries Korea, Taiwan and Indonesia, but Korea joined the Commission in 2002, and Taiwan as a member of the “extended community”. Over-fishing of the stock is still occurring and it is unlikely that stock recovery will be achieved by 2020. World-wide concern over the state of stocks has resulted in the species being listed as critically endangered by the World Conservation Union. As discussed by Kolody et al. (2008) during 2002-2006 the Commission engaged in a multi-lateral process to develop, and simulation test, a Management Procedure (MP) for the SBT fishery. Consensus was reached in 2005, and the MP was adopted in principle, however in 2005-2006 data problems were identified (the long-term under reporting of catches), which undermined confidence in the process. As a result the MP implementation was suspended and implementation is not expected to begin until 2011, at the earliest. This example highlights the difficulty of managing a stock that is fished by many different nations and managed under a RFMO.

The tuna fishery of the western and central Pacific Ocean is one of the world's largest fisheries. A large proportion of catch is taken within the EEZs of Pacific Island countries, for which tuna represents their only significant natural resource and provides the only source of foreign revenue via licensing of foreign fishing fleets. As discussed by Langley et al. (2009) from the mid 1990s it was recognised that a RFMO was required to facilitate co-operation in the management of the resource, and the Western and Central Pacific Fishery Commission (WCPFC) was established in 2004. The RFMO is responsible for ensuring the long-term sustainability of highly migratory fish stocks in the western and central Pacific Ocean. Despite concerns regarding stock levels and increased mortality for yellowfin and bigeye tuna, to date the WCPFC has not been able to introduce measures to reduce or limit the level of fishing mortality. While significant reductions in the current level of fishing mortality is needed to ensure that yellowfin and bigeye tuna stocks are not over-fished, there is pressure from developing coastal states wishing to expand domestic fleets; access opportunities for new entrants; and distant water fishing nations wish to maintain current share in the fishery.

4.3.3 Bilateral arrangements

Governance and management responses for any two nation states are developed and implemented through a range of bilateral agreements, integrated management plans, or memorandum of understanding (MOUs). The two nation states may also be members of a regional group with responsibilities at the regional level as well as responding in accordance with the international agreements they are party to. As outlined by Edeson (2005 pp. 18-26) the LOSC provisions deal with conservation, management and utilisation of living marine resources, and nation states are charged with co-operating to ensure sustainable management of shared marine resources. These issues are difficult enough for single nations and are compounded when considering shared resources.

Governance and management of shared resources, and management arrangements need to be resilient over time to be able to cope with unexpected environmental, economic and political events. In the case of shared fish stocks co-operation between the two countries is very important for managing these resources on a sustainable basis, especially if the management goals of each nation State are different. The issues that need to be addressed include the collection of biological data to enable understanding of the species such as stock structure, abundance and distribution. These data provide a basis for agreeing on a mechanism for resource allocation, and development of harvest strategies, that aim to ensure resources are not over-exploited. Monitoring and enforcement regimes are also important to bilateral governance and management regimes. When considering the economic and social issues in respect to equitable sharing of benefits, the nation states need to consider the issues both in terms of equity between the two nation states, and within their respective nation states (Munro et al., 2004).

4.3.4 Nation states

As discussed above nation states are required to work co-operatively and collaboratively with each other at international, regional and bilateral levels. Nation states are also responsible for managing oceans and fisheries within their own EEZ. Nation states have responsibility to comply with international agreements they are party to, and for incorporating the requirements of these into national arrangements, including the implementation of EBFM, if adopted as a policy goal. This may mean changes to the domestic governance and management arrangements, and ocean and fisheries practices. This represents a wide diversity of roles and responsibilities required of nation states. According to Meadowcroft (2007) although many countries have now accumulated experience with sustainable development, others are still preparing plans and strategies. The ideal strategy as elaborated in the international literature is one of a fully integrated process of strategic decision-making involving institutional cycles of choice, planning, implementation, monitoring and reassessment. It also requires public participation and the integration of the environmental, economic and social dimensions; adoption of long-term objectives and measurable targets; and vertical and horizontal policy coherence. As discussed in Chapter 2, under the Convention of Biological Diversity, does not mandate a single way to implement the ecosystem approach, recognising the importance of local and national conditions. Chapters 6, 7, and 8, give details on Australia’s approach and response to sustainable development and adoption of EBFM will be described and discussed.

4.4 Governance and management: multiple institutions and stakeholders

The development of international instruments and agreements and application of the EBFM approach is characterised not only by a multi-level governance and management system, but also a multiple institutional and stakeholder decision-making system. Institutions operate at multiple levels of jurisdiction and may be linked to each other and form networks of interactions. Institutions are social constructs, which provide a framework, structure, order and predictability into human relations and interactions. In terms of what may be expected, such as rights, roles, responsibilities, agendas, standards and practices; shared norms that instil social order and shape human incentives which provide stability and meaning to social behaviour; and embody knowledge. The political agenda and policy selection is driven by societal objectives that are a reflection of the values, preferences and behaviours of individuals and organisations within society, which can and do change. Institutions convert values into goals. Fisheries governance and management have many goals to fulfil, stakeholders have multiple objectives for marine ecosystems and these involve trade-offs. Moving towards EBFM requires an explicit consideration of these multiple objectives (Hanna, 1999; Rudd, 2004; Jentoft, 2004).

The issue of institutional power and legitimacy is important for effective governance and management. No single agency can achieve legitimacy and effective governance, it requires interactive structures, processes and communication between them and stakeholders (Jentoft, 2005 pp. 147-151).There are two aspects relating to governance and management structures, the array of management objectives, and the efficiency with which they are organised. There is no best governance structure as all involve trade-offs between stability and flexibility, authority, and representation of the social and individual. The function of governance and management is to provide stability and consistency for decision-making, while retaining flexibility to adapt to changing conditions. Fisheries governance and management functions include exclusion of unauthorised users; regulation of authorised users and distribution of benefits and cost recovery; monitoring and enforcement; conflict resolution; and collective decision-making. Governance and management institutions are shaped by different cultures and values, and therefore may be organised and function differently (Hanna, 1998, Hanna, 1999; Paavola, 2007). The institutional aspects to be discussed next include:

participatory decision-making considered a key element that underpins the EBFM approach; and different governance and management approaches and arrangements.

4.4.1 Participatory decision-making

According to Jentoft (2004) society and fisheries are often regarded as comprising three social institutions: the state; market; and civil society that operate at multiple levels of jurisdictions, and which are linked and form networks. These three institutions are different in that they embody and pursue different social values, goals, functions and working principles. The EBFM approach stresses the importance of consultation and broadening stakeholder participation in governance and management decision-making, and the inclusion of all stakeholders that have an interest in oceans and fisheries governance and management. A participatory decision-making process will also require the resolution of conflicting objectives and interests, and capability and capacity building.

Participatory decision-making

A participatory framework for decision-making considers all stakeholder interests and is inclusive, consultative, and participatory. Oceans and fisheries stakeholders include individuals; communities; the broader society; economic and market players; government and institutional agencies and mangers; fishing industry and fishers; and Non-government Organisations (FAO, 2003). Stakeholders need to be able to understand the basis for decisions, and to participate in decision-making across a wide range of issues and process. The aim of participatory decision-making is to gain broad support from a wide range of stakeholders (Sissenwine and Mace, 2003).The issues to be managed are complex and require judgement and agreement by fisheries mangers and the industry as well as others who have an interest in marine ecosystems (Ward et al., 2002). Many western countries have adopted more participatory and consultative methods for dealing with complex issues such as environmental and social impact assessments; participatory models of planning; right-to-know legislation; public hearings and enquiries; regulatory negotiations; and environmental mediations. However, to be able to participate effectively, people will have to become aware of political, economic and science parameters for decision-making (Dryzek, 1992).

The introduction of EBFM has meant changes in decision-making processes; it expands the number of government agencies and other institutions involved; requires greater stakeholder participation, which increases the number of people to be consulted, involved in negotiations; and decision-making at all levels. This situation requires the development of mechanisms and forums for participatory decision-making, which also recognises and deal effectively with the different values and interests of stakeholders, and goals and objectives of institutions, and organisations. These may not be easily reconciled and may lead to tensions and conflicts (Johnson et al., 2005; Sutinen and Soboil, 2003). Suarez de Vivero et al. (2008) suggest that the process of broadening stakeholder participation has resulted in fishers and fisher communities losing prominence as they are just one part of a spectrum of interests in the decision-making process.

Resolution of conflicting objectives and interests

EBFM requires decisions to be made for the long-term as many of the ecological processes span decades, and pose new challenges to the ways we define problems, identify solutions and implement actions. This may confront decision makers with dilemmas that require hard choices, such as how to deal with over-fishing or over-capacity; the allocation of resources between different sectors and users; or short-term versus long-term development choices. Choices are related to alternative courses of action on the basis that one is considered better in relation to a particular goal or purpose. All choices are linked to the issue of values. Easy choices are characterised by comparable, commensurable and compatible values, and can be dealt with on the basis of exchanges between, or within, the scope of one value. Moderate choices involve mixes of comparable and commensurable values and make trade-offs between these values. Hard choices are where the values are incomparable, incommensurable and incompatible and are of an either or type. Therefore, governance and management of fisheries requires thoughtful debate on basic values and principles, especially in the case of hard decisions (Kooiman and Jentoft, 2005 pp. 285-299).

Lackey (1998 p. 23) argues the range of views regarding ecosystem management is wide, and suggests that ecosystem management problems may be characterised as:

- fundamental public and private values and priorities are in dispute, resulting in partially or wholly mutually exclusive decision alternatives;
- there is substantial and intense political pressure to make rapid and significant changes in public policy;
- public and private stakes are high, with substantial costs and risk of adverse effects to some groups regardless of which option is selected;
- the technical facts, ecological and sociological are highly uncertain;
- the ecosystem and policy problems are meshed in a large framework such that policy decisions will have effects outside the scope of the problem;
- ecosystem management reflects a stage in the continuing evolution of social values and priorities; and
- that the decision-making process is fundamentally one of public or private choice.

Attention is often focused on the goals and means, whereas an alternative view to decision-making would focus attention in the following order values: concerns, principles, goals, and means. The process through which these are determined needs to be open, transparent and participatory. Learning needs to be inclusive and interactive, as concerns and moral values may prove to be inadequate and may need to be redefined. Also the institutional arrangements and measures at any level may prove ineffective and therefore may need to be corrected or changed (Kooiman and Jentoft, 2005 pp. 297-299). Outcomes from the use of regulations and enforcement activities may be more immediate and publicly visible, whereas results from communication and education programs take longer, however they can change behaviour which may reduce management costs in the long-term (Kay and Alder, 2005 p. 170).

Capacity and capability building

Meeting the challenges of EBFM will require capability and capacity building through mechanisms that inform and facilitate societal choice and decision-making. It will need to include an improved understanding of ecosystems; training for managers and regulators to enable them to deal effectively with the levels of complexity regarding

EBFM issues, options and trade-offs; enhancing stakeholder capacity to fully participate in decision-making processes through education; and providing the necessary information in a timely and suitable format (FAO, 2003). Capacity describes initiatives aimed at increasing the capability of decision makers, and improving decision outcomes within supporting institutional frameworks. Human capacity is focused on training, and professional development, whereas institutional capacity aims to improve governance and management arrangements, and includes communication and education (Kay and Alder, 2000 pp. 168-170). The match between stakeholder capacity and responsibility is important so that stakeholders are not expected to assume unrealistic responsibilities. It should be noted that development of capability and capacity building takes time and resources (Mahon et al., 2005 pp. 368-369).

The development of an enabling environment represents the societal context in which development processes take place, and builds on existing capacities. Enabling mechanisms need to be developed at the organisational, sector, and individual levels. The organisational and institutional level focuses on organisational structures, processes, resources and management issues. This can for example, be reflected in good governance and policies. The sector level represents the need for coherent sector policies and strategies, as well as co-ordination across sectors, and may include initiatives such as sector reform or service delivery at the sector level. The individual refers to individuals working within organisations and institutions, or being affected by them, at any level. Individuals will also need to develop a range of skills to be able to effectively participate and contribute (Macfayden and Huntington, 2004 pp. 1-2). Financial capacity is also needed in the form of adequate financial resources to carry out planning initiatives and implement management measures. Technical capacity in terms of information gathering, establishment and maintenance of databases and information systems are also important (Cincin-Sain and Knecht, 1998 pp. 60-61).

4.4.2 Governance and management: different institutional approaches

There are different styles or modes of governance and management arrangements between the State and its citizens. Hierarchical governance is characterised as a top down and regulatory. Self governance is where governments may deregulate or privatise, withdrawing from the public sector, or by incorporating self regulating capacities within governance frameworks. Co-governance, co-management or partnerships is where there is a shared responsibility between the governance and management institutions, and stakeholders. Generally all societies demonstrate and require a mix of all three. Government style and the different management approaches are linked. The spectrum of government may at one end be based on a centralised command and control, or at the other end decentralised under self management approaches, or a combination of approaches at the different levels depending upon the issues. Different management approaches may also be designed to manage at different environmental scales and/or by different institutions and organisations, requiring co-operation between a wide range of stakeholders (Kooiman and Bavinck, 2005 pp. 21-22). Discussions regarding centralisation and decentralisation and co-management arrangements are outlined below.

Centralisation and decentralisation

It is often argued that decentralisation of management responsibility to the local level has the potential to improve compliance, and the cost effectiveness of management. Many authors support the notion of decentralised governance and management (Korn et al., 2003; Mangel et al., 1996; Grumbine, 1994; Christensen et al., 1996), although this is not unanimous, as Hartje et al. (2003) conclude, for example that decentralisation is not necessarily the answer to management problems. Devolution is not a self evident process as there are many political obstacles and diverging interests. Demands for decentralisation tend to oversimplify the problem, and often there is a need for mechanisms to resolve interregional conflicts and consideration of national or international interests. There appears, however, to be a broad consensus regarding the issue of decentralisation and awareness of placing local issues and interests within a larger framework of decision-making (Hartje et al., 2003 pp. 18-19). It is acknowledged that decision-making from an ecosystems perspective will require decisions to be made at a number of different levels (Thorne-Miller and Catena, 1991; Ecosystem Principles Advisory Panel, 1999; FAO, 2003; Sissenwine and Mace, 2003). Therefore, from a multi-level and multi-institutional perspective effective governance and management, is dependent upon decisions that must be taken both at the central government level, and through the devolution to, and participation of local communities, which should complement larger-scale national activities (Hartje et al., 2003 pp. 18-19).

Article 2 of the Convention on Biological Diversity (1992 p. 3) notes that, “an ecosystem means a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit”. The Convention does not specify any particular spatial unit or scale. According to Korn et al. (2003), therefore, the scale and analysis and action should be determined by the issues being addressed which may range from small-scale such as a pond to a catchment, or large-scale biome (Korn et al., 2003 pp. 18-19). Hartje et al. (2003), argues that the management level needs to be adequate to deal with the issue, which may require attention at a number of different levels. The marine environment has unique characteristics in terms of open and dynamic systems with complex physical, chemical and biological interactions; with variation in spatial and temporal patterns and processes (Hartje et al., 2003 p. 17). This makes the issue of matching institutional jurisdictions and ecosystems boundaries difficult. The jurisdiction of governance and management institutions often do not match the ecosystems boundaries or stock boundaries of fishery resources, but the ecosystems and boundaries are not the only issue, it will also require alignment between institutions at the different levels. It will also require sufficiently flexible institutions, but practical experience in this sphere is limited.

Co-management arrangements

Studies of fisheries governance in recent years has focused on the concept of participative governance and co-management systems (Symes, 2006). As discussed by Suarez et al. (2008) co-management fits with the new interactive governance approaches. As outlined by Smith et al. (1999) challenges for fisheries management agencies world-wide are characterised by multiple and conflicting objectives, multiple stakeholders with divergent interests and high levels of uncertainty about the dynamics of the resources being managed. One response to these concerns has been a move to include industry and stakeholders in management processes, and this approach has been called co-management. According to Chuenpagdee and Jentoft (2007) in the last ten years most of the studies have focused on how co-management systems are implemented, with much less attention on what precedes implementation. Learning about the pre-implementation steps would help to decide whether is should proceed and under what conditions is it likely to succeed. Sen and Neilsen (1996) defined co-management as an arrangement where responsibility for resource management is shared between the government and user groups. Community based resource management are considered different to co-management because government is often not involved in the decision-making processes.

It is generally regarded that effective management of fisheries requires co-operation and participation of fishers to make governance laws and regulations work. Co-management is the sharing of responsibility and authority between the government agencies, the fishing industry and fishers in managing the fishery. This includes various partnership arrangements and different degrees of power sharing. Co-management systems have developed as a partnership arrangement in which the capacities and interests of local fishers and communities are complemented by the government in providing enabling legislations, enforcement and conflict resolution, and other assistance. A feature of this approach is decentralisation, which may take the form of delegation, devolution or privatisation. A key question is what functions are best handled at the local level versus the national level. The role of government in establishing conditions necessary for co-management arrangements include legitimacy and accountability for the local organisation, and institutional arrangements, as well as through legislative and policy instruments that define power sharing and the decision-making arrangements (Pomeroy and Berkes, 1997).

In theory co-management has the potential to improve compliance of agreed rules and the sharing of information. It may also be more effective in terms of more accurate resource assessment at the local level, and the ability to change the management rules more quickly in response to issues (McCay, 1996 p. 120). The co-management approach is a mechanism for sharing decision-making, management functions, and resolving conflict between stakeholders. Participation in co-management may include governments; fishers, other fishery sector players; community organisations; and the general public. Participants have both rights and responsibilities in the co-management arrangements, which may include a range of options, and different levels of co-management between government, users and community management. At the local level co-management including community based management and partnering arrangements increase fishers, participation through joint decision-making and by transferring some management rights and responsibilities. For this approach to be successful requires a well defined process so that both the government and participants understand their rights and responsibilities (Charles, 2001 pp. 263-276).

The extent to which government may influence decisions under a co-management model varies from one where government makes the decisions but consults with the stakeholders, to a delegated model where fishers design, implement and enforce laws and regulations, with advice and assistance from the government, however no one size fits all solutions. The approach will vary depending on the resource and the issues, and covers a broad spectrum of possible collaborative decision-making between governments and stakeholders. Generally a delegated model will only be effective for small, homogeneous stakeholder communities and where there is single species and issue focus, and strong property rights with effective governance and accountability. Co-management also describes a continuum of management arrangements where resource management responsibilities are shared, and covers various partnerships agreements and degrees of power sharing at different points along the continuum (as per Figure 4.4.2 below). Co-management should not be viewed as a single strategy for fisheries resource management, but as a set of alternative management strategies appropriate for certain areas and situations. Regardless of the co-management arrangements adopted, government must retain the capacity to manage the fisheries resources in the public interest (Sen and Nielsen, 1996; Department of Primary Industries, 2007).

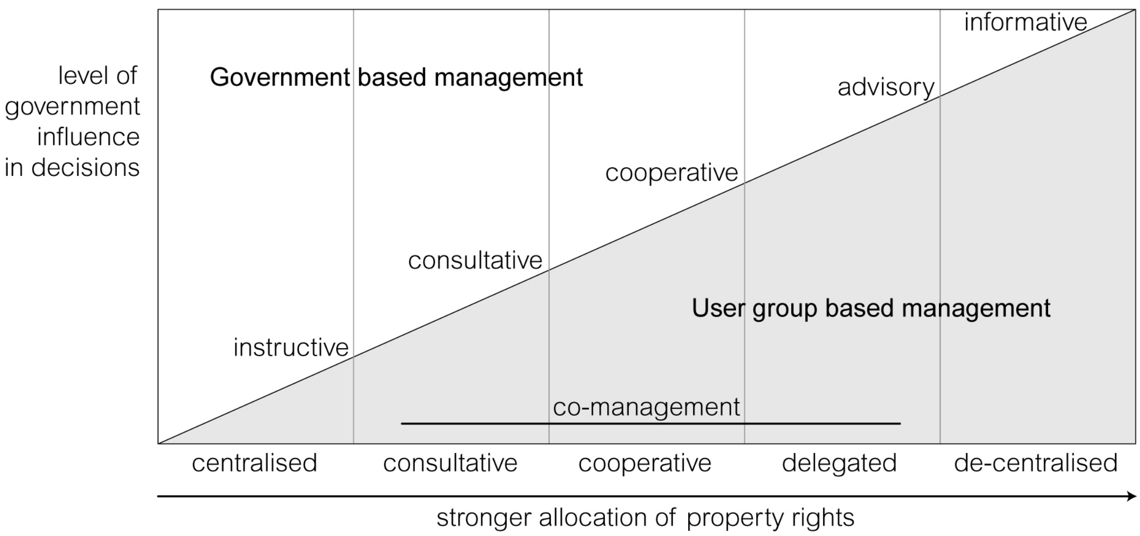


Figure 4.4.2: Continuum of co-management approaches (Department of Primary Industries, 2007 pp. 5-6).

4.5 Integrated governance and management

An international consensus has emerged regarding the imperative of managing multiple ocean and coastal uses through an integrated approach. When considering integrated governance and management in relation to ecosystems and human systems there are two fundamental issues, first that of understanding the whole system and, second that of the individual components. Breaking the whole system into component parts provides a perspective and an understanding of the issues, roles and responsibilities at each level. This perspective and understanding helps in developing mechanisms for integrating within and across the component parts, and within and between each level in a manner that recognises the key interconnections, interdependencies, and interrelationships as they relate to the whole system (Johnson et al., 2005 pp. 133-144). Aspects relating to integrated governance and management are presented below.

4.5.1 Environmental, economic and social integration

Governance policies and management initiatives are developed in response to environmental, economic and social concerns at a range of spatial and temporal scales. Qualities of comprehensiveness, consistency, and coherence are of importance when developing a governance response and selecting management actions. Comprehensiveness is important in dealing with issues at the relevant scale or scales, when considering the environmental, economic and social dimensions, so that mitigation and management actions are effective. Consistency is important when translating from general concepts and guidelines as outlined in the international agreements, into principles and criteria for governance and management objectives, and specific approaches and actions, for implementation, at regional, national and local levels. Coherence is important in terms of the overall suite of governance and management policy initiatives in response to a range of issues and across broad policy goals and management arrangements (Arkema et al., 2006).

Management approaches for integrating at a range of spatial scales (that also consider the integration of the environmental, economic and social parameters) include, Large Marine Ecosystems Management (LME) and Integrated Coastal Zone Management (ICZM). LME is based on the principle that a large-scale systems approach which simultaneously considers ecosystem processes, and human activities provides management with the best chance for finding sustainable solutions. It is also concerned with human activities that alter ecosystems, which in turn reduces the ability of ecosystems to support human populations and economies. A LME strategy is defined along large-scale hydrographic regimes, with a focus on ecosystem dynamics and fisheries, and is largely science driven (Griffis and Kimball, 1996; Cicin-Sain and Belfiore, 2005; GESAMP, 2001; Kay and Alder, 2005).

ICZM focuses on influencing policy and governance processes (more issues driven) to shape patterns of coastal resource use through changes or modification in human behaviour and social values (people management). What distinguishes ICZM from coastal management or coastal resource management is the development of a governance system capable of managing multiple uses in an integrated way through the co-operation and co-ordination of government agencies at different levels of authority, with non-governmental organisations, and among different economic sectors. More recently it has been realised that ICZM efforts must also be tied to terrestrially oriented catchment management. Catchment management is a similar approach to ICZM, which aims to manage the impacts at the land and marine interface in an integrated manner (Griffis and Kimball, 1996; Cicin-Sain and Belfiore, 2005; GESAMP, 2001; Kay and Alder, 2005). Multiple-Use-Management (MUM) offers an approach to achieving an ecologically sustainable balance of outcomes across a broad range of uses and users of the environment, and overcoming the cumulative impacts of single sector governance and management. This approach provides a framework, which has the potential to overcome the problems caused by sectoral decision-making; provide the basis for integrated planning and analysis at global, national, state and local levels; and provide the context for assessment of policies, plans, programss and individual projects (Sainsbury et al., 1997 pp. 4-5).

4.5.2 Multi-level governance and management

Governance and management systems and arrangements operate at different but interconnected spatial scales from the international to the local levels; and within different jurisdictional boundaries, which confer different authority at these different levels. Cole (2003) discussed the complexity of multi-level governance and management as a result of globalisation and global interconnectedness. Global interconnectedness has developed in terms of economics, politics, technology and law, which Cole (2003) argues has altered state authority in fisheries governance and management, with issues and decision-making processes being considered and made at the international, regional and national levels. The international economy in terms of production and trade has created new forms of interaction beyond those of the nation state, with fish markets increasingly being internationalised. Policy making has changed requiring international co-operation, with a range of organisations holding authority on global fisheries management. The development of international law has created differences between formal political authority claimed by nation states, and the actual practices and structures of the state at the national, regional and global levels. Stakeholders realign their representation at these different levels and respond to the changes in law, economics and institutions.

As outlined in Section 4.2 important factors with regard to governance and management, are the structures and functions of institutions, and their respective roles and responsibilities at different jurisdictional levels, and how these have changed with the introduction of EBFM. As discussed in Section 4.3 multi-level governance and management is now part of oceans and fisheries decision-making. In some respects this might be viewed as containing a hierarchal quality from the international to the local level, however it could also be viewed as decision-making system nested within successive levels from the local to the international; and each with different respective roles, responsibilities and authority. These aspects are presented in Figure 4.5.2 which represents a systems approach to multi-level governance and management, that encompass the biosocioeconomic context, issues and concerns; the governance and management roles and responsibilities; and the structure and function of governance and management institutions and issues for consideration at the different jurisdictional levels.

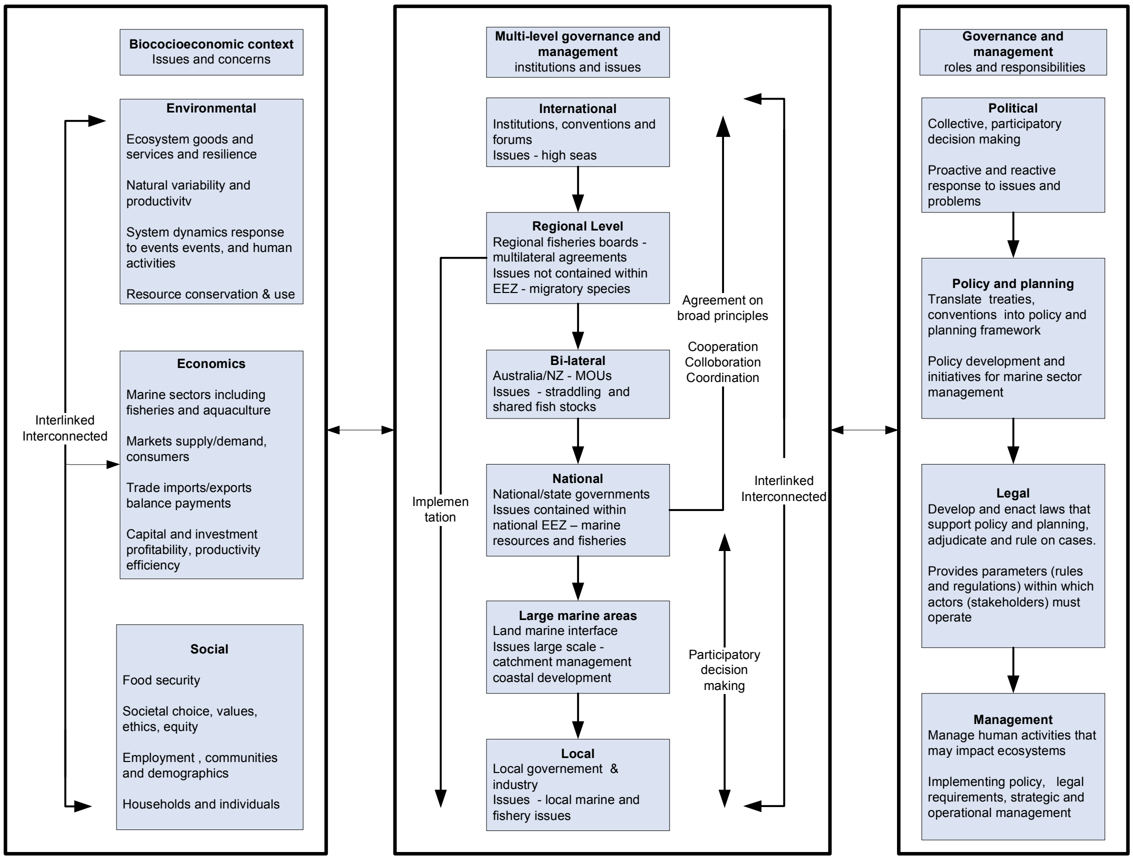


Figure 4.5.2: A systems model of multi-level governance and management.

4.5.3 Multiple institutions and stakeholders and participatory decision-making

An important element of EBFM is participatory decision-making. This expands the number of agencies involved and has broadened the practical operation of governance and management, requiring the participation of a wider range of organisations and stakeholders at all levels from the international to the local level. These organisations, institutions and stakeholders often have different overarching goals and objectives (Suitinen and Soboil, 2003). According to Berghofer et al. (2008) EBFM requires an understanding of the social-ecological system. The inclusion of stakeholder interests in decision-making implies value judgements when societal choices need to be made. In multi-level and cross sector systems both institutions and stakeholders may be situated at a number of levels (each with different concerns, interests and values). In theory stakeholder participation has the potential to overcome some challenges in implementing an EBFM approach by taking into account these different viewpoints and values in decision-making, which implies a shift from a functional and structural organisation to a more explicit consideration of locations and procedures in resource management. EBFM involves a new framing of management tasks; sharing of knowledge and information; the generation of management options; and final decision-making. According to Berghofer (2008) this will emerge from an interactive process between institutions and stakeholders. The type of relationships and the nature of interactions will differ, depending on the roles that institutions and stakeholders undertake at the different levels of the decision-making process.

How effective participatory decision-making is to be achieved is a challenge for fisheries governance and management, in terms of developing mechanisms for co-operation, co-ordination, and collaboration within and across institutions and the involvement of relevant stakeholders at the different jurisdictional levels (Pascual-Fernandez et al., 2005). Figure 4.5.3 represents this multi-level institutional and stakeholders decision-making framework, and illustrates the complexity between institutions, organisations and stakeholders (horizontal complexity), and at the different jurisdictional levels (vertical complexity). Fisheries systems both set the context for governance and management and also operate within their own governance and management arrangements as stakeholders as part of the participatory decision-making process.

Governance and management institutions and stakeholders (horizontal)

← mechanisms for co-operation, coordination and collaboration, within and across institutions and stakeholders participation →

Multi-level governance and management (vertical)

←---mechnisms to maintain interactions, interlinkages and interconnections at and between levels ----------->

	Biosocioeconimc context Issues: at different spatial and temporal scales			Governance and management Institutions, organisations and stakeholders: with different roles, , at and jurisdictional responsibilities			
Levels	Environment	Economic	Social	Political	Policy and Planning	Legal	Management
International	High seas and highly migratory species	Globalisation trans national corporations	Regional and bi regional delegates National delegates NGOs	International institutions	U. N or similar organisations	LOSC CBD Conventions Treaties Agreements	FAO or similar organisations
Regional	Oceans and seas	Trading blocks more than two nations	National delegates	RSPs & RFBs institutions	RSPs & RFBs organisations	Multi lateral agreements	RSPs & RFBs management organisations
Bi-lateral	Oceans and seas	Trading partners two nations	National delegates	Bilateral institutions	Bilateral organisation	Bilateral agreements	Bilateral management organisations
National	EEZ	Sectors Corporations Corporations	Represented by MPs NGOs	Parliament Parties NGOs	Government ministry and agency	National Acts and regulations	Sector management within and between
States	EEZ	Sectors	Represented by state ministers	State parliament parties	State agencies	State acts and regulations	Sector management
Large Marine Areas	LME Land marine interface	Sectors	Formal/informal organisations NGOs	Formal/informal institutions, groups	Formal/informal organisations	State acts and regulations	Sector management Industry Integrated coastal & catchment management
Local	Ecosystems	Individuals Local companies	Communities Households Individuals Formal/informal groups	MPs	Local councils Formal/informal organisations	Local byelaws and regulations	Local firms and fishers

Figure 4.5.3: A multi-level institutional and stakeholders decision-making framework.

4.5.4 Institutional interplay and fit

An outcome of multi-level governance and management, and multiple institutions and stakeholders decision-making, can result in issues of interplay and fit. Governance and management institutions and stakeholders have to operate in a complex environment. Changing ecosystems and human systems issues are closely interlinked and interact often in an unpredictable and surprising manner, at a range of interdependent spatial and temporal scales. National issues and governance and management regimes are nested within wider regional and global systems. Institutions may be linked in ways that affect their individual and collective performance. Institutional interplay may occur among institutions at the same level of social organisation (horizontal interplay) or among institutions at different levels of social organisation (vertical interplay). Institutional interplay refers to those situations in which the content, operation, or consequences of one institution influences other institutions. Interdependence between institutions can result in regime interplay if an issue or the functional areas overlap, or where policy goals and regulations intersect. This may result in conflict if interactions obstruct policy objectives, or may be complementary if interactions reinforce policy objectives of each. The issue of institutional fit is the extent to which the scope and authority of institutions match the biophysical environment and natural resources to be managed across jurisdictions. Social institutions and ecological systems have different dimensions that can be defined temporally and functionally. The space that institutions operate within may overlap or interact. For example, the protection of a highly migratory species or the management of straddling or shared fish stocks will require a collective governance and management response at the international, regional and national level; as well as the local level including fishers and fishing companies who have an interest in, and access to the resource (Charles, 2001; Pascual-Fernandez et al., 2005; Sydnes et al., 2005; Kim, 2004; Hoel et al., 2005; Ekstrom et al., 2009). According to Grafton et al. (2008) positioning fisheries in a changing world requires communication between the public sector and civil society; effective vertical and horizontal connections among stakeholders; and coherent linkages across priorities; and adaptation to change in ecosystems and human systems.

As Meadowcroft (2002) highlights the increase in the diversity and specificity of the governance and management approaches and initiatives being introduced are being layered on top of existing governance and management frameworks and pre-existing initiatives, which were in response to problems at a range of different spatial scales. The market based incentives and participatory approaches have not supplanted command and control approaches but have been added to them. This approach emphasises broader scales and locating problems and solutions in terms of wider contexts, leading to more varied and complex practices; and widening the range of social actors; and more differentiated perspectives. Together these add to the diversity and complexity of governance systems.

Meadowcroft (2002) argues, there will be limits to the extent that it will be possible to reconcile institutions into a single hierarchy, or implement a fully integrated approach to managing environmental issues. However, it is still important to attain coherence across policy domains and to try and achieve co-ordination between different institutions. While it may be important to establish new organisational frameworks to deal with environmental issues that are not adequately addressed by current institutions, this does not necessarily mean replacing old systems. It may be more appropriate or effective to involve representatives from existing bodies into co-operative, collaborative, trans-jurisdictional and inter-jurisdictional arrangements, in response to dealing with a particular issues, or suite of issues. It takes time to develop a more comprehensive response to issues and co-ordination and co-operation within and between institutions to manage ecosystem and human issues. Changing environmental, economic and social conditions will also mean continued innovation in governance and management approaches, in response to new learning, requiring flexible but robust institutions.

4.6 Decision-making: complexity, uncertainty, risks, adaptive management and evaluation

Diversity is a characteristic of ecosystems and human systems. Complexity is related to the relationships and interactions within and between the parts of these systems. Diversity and complexity are reinforced by dynamics which apply to tensions within and between systems and are associated with change. The range of oceans and fisheries issues has changed over time and will continue to change, as will the drivers of these changes. Globalisation has also contributed to the changes and complexity of oceans and fisheries governance and management. Diversity, complexity and dynamics operate at a range of spatial and temporal scales and are an important characteristic of these systems (Kooiman and Bavinck, 2005 pp. 13-14). Understanding these aspects is important for developing effective governance policy initiatives and efficient management measures for dealing with current and emerging oceans and fishery issues; and for predicting the response of the fishery systems to governance initiatives, and management actions. As a result of this diversity and complexity it is not possible to apply a universal system of governance and management, as it requires multiple and flexible approaches in response to changing situations, with an ability to read the signs that indicate change, and the capacity to learn and respond adaptively (Johnson et al., 2005 pp. 133-14; Mahon et al., 2008 pp. 369-372).

Governance and management are required to explicitly take into account uncertainties, risks and consequences and the inherent unpredictability in ecosystems and human systems, at a range of different spatial and temporal scales (Costanza et al., 1999). This is particularly important when providing advice or considering governance and management strategies and options. Uncertainty may be due to many different and unpredictable factors, such as the natural variability of ecosystems and difficulties of assessing fish stocks, or the response of ecosystems to natural disturbances or events, as well as human perturbations. Uncertainty in human system may include changes in global markets; variations in supply and demand for fish products and fish prices, or consumer preferences; technological changes in fishing power; and fisher objectives and response to governance and management changes and regulations or governance and management (Charles, 2001 pp. 201-209). Management of fisheries may also be affected by institutional uncertainties which can arise from various sources and attributes within institutional regimes and interactions between institutions. Also, the objectives of governance policy and management actions may not result in expected outcomes (Young, 1998).

The incorporation of EBFM principles into governance and management arrangements also requires a broad multi-disciplinary approach that recognises a range of information both qualitative and quantitative, and includes local and traditional knowledge for informed decision-making. Improved knowledge of fishery systems and governance and management options are important to ensure that governance initiatives and management actions can be monitored and adapted in response to the lessons learned, thus enabling an interdisciplinary approach and enhancing knowledge in a systematic manner (Bavink et al., 2005 pp. 321-322) An interdisciplinary approach is one in which the collaborators are working to a common plan that enables an emerging consistency of theoretical underpinning (Symes, 2007). Although discipline based research is necessary as it provides insights into mechanisms and processes, it is focused on subsystems and cannot provide a systems wide understanding. Efforts are being made to develop interdisciplinary and trans-disciplinary approaches which encourage integration (Newell et al., 2005). Establishing fishers' knowledge in formal consultations and integrating fishers' experience-based knowledge with scientific research-based knowledge is a challenge. Different mandates and tasks may influence the motivation and flexibility of participants, particularly if there are difficult conflicts or trade-offs to be made, and where information may be used strategically. Under these circumstances trust in the other participants, confidence in the process, and the quality of interactions and building social capital are important factors (Berghofer et al., 2008).

Stakeholders often have limited or poor quality information for decision-making, and even with good information it is difficult to predict that a particular outcome will occur as a result from a particular action (Bavinck et al., 2005). Knowledge of coupled ecosystems and human systems is uncertain. Complexity and uncertainty raise questions at what jurisdictional level institutions and stakeholders should inform fisheries management. Uncertainty increases the degree to which knowledge is a product of negotiation rather than consensus (Berghofer et al., 2008). There are uncertainties due to the limited nature of data and the resulting imprecision in the parameters estimated in fishery models. An important factor regarding complexity and uncertainty is how the dynamics of these create risk and the associated consequences in fishery systems, as well as developing a means of dealing with them (Charles, 2001 pp. 207-210). The management system could be considered as a mechanism to reduce and deal with the different types of uncertainty, and consider any residual uncertainty, in order to make the best management decisions and implement effective management measures. Such a management approach is adaptive management (Cochrane, 1999). When judged from a long-term perspective many policies result in unexpected side effects, as governance and management underestimated the importance of feedback effects, non-linearities, time delays and changes in human behaviour as a consequence of governance interventions. More recently the overall trend has been an increased awareness of the complexity of systems and management as learning process, rather than control when dealing with complexity and uncertainty (Phal-Wostl, 2007).

4.6.1 Adaptive management

Adaptive management has been proposed as a way to deal with uncertainty when managing dynamic and complex ecosystems and human systems (Folke et al., 2000 pp. 10-11). In the past uncertainty has often not been well considered in decision-making, but the need to formally incorporate procedures for the acknowledgment and treatment of uncertainty has now been recognised (Harding, 1998 p. 164). Adaptive management is often described as a process of learning by doing and then incorporating lessons learned into decision-making. This approach requires flexibility towards change, and an openness with regard to learning (Hartje et al., 2003 pp. 15-16). Adaptive management provides management with a mechanism to anticipate and cater for ecosystem changes and events, to be cautious in decision-making that might foreclose future options, and a process for continual improvement. Adaptive management assumes that scientific knowledge is provisional and focuses on management as a learning process. Management can learn from experience, and management actions and policies can be considered as experiments based on hypotheses about ecosystem and human system responses, but this will require effective monitoring to assess outcomes and test any hypotheses (Korn et al., 2003; Mangel et al., 1996; Grumbine, 1994; Christensen et al., 1996; Ecosystem Principles Advisory Panel, 1999).

As highlighted by Michel (2009) the adaptive governance approach is in response to the changing, interlinked and interdependent nature of ecosystems and human systems; the inherent uncertainties and complexities of these systems; and the reciprocal feedback loops. Governance seeks wide participation in adaptive policy processes to expand the information base underpinning policy design and decision-making, for the purpose of better governance outcomes. However in coupled ecosystem and human systems, governance and policy measures may result in unintended outcomes and will therefore require ongoing monitoring and revision to meet stated objectives. As Charles (2001) discusses there is still much to learn about ecosystems and human systems. Ecosystems and human systems are dynamic therefore managers must be willing to amend management objectives and practices in response to unexpected and unacceptable outcomes. As discussed by Walters and Holling (1990) and Charles (2001 pp. 211-212) the ideas underpinning adaptive management are to recognise and take into account the uncertainty in fisheries management, and incorporate new information to improve the knowledge base on which decisions are made. This can be either through passive or active approaches. Passive adaptive learning is described as a process where parameter estimates are updated as new information becomes available. Active adaptive management is described as a deliberate attempt to accelerate learning by exploring the system experimentally.

According to Linkov et al. (2006) adaptive management explicitly acknowledges uncertainty and seeks to minimise uncertainty by learning about the system to be managed. As a result no single best policy can be selected, but instead a set of alternative options can be tested to ascertain the effects of the different actions. Although adaptive management is often recommended with regard to EBFM, implementation to date is limited. Application of the concept varies and there is no framework that robustly incorporates it into environmental practice. As outlined above there are two types of adaptive management, passive and active, and both begin with goal setting; modelling the system, and selecting and implementing a management strategy. The passive approach involves implementing one strategy at a time, whereas in the active approach multiple experimental alternatives are examined (hypothesis testing) with a control to isolate factors which affect the system. The managed system is then monitored to ascertain effects of the strategy on the system; the strategy is evaluated and adjusted; and the goals and objectives for the project may also need to be revisited and revised (Linkov et al., 2006 p. 1080).

A review of the literature by Linkov et al. (2006) regarding the development and application of adaptive management indicated the following. A key element is a regular review of a project’s objectives, and stakeholders must agree on what the basic objectives are, and these should be reviewed as new information becomes available. This aspect was rarely discussed with many taking it for granted that the objectives are static goals. Modelling tools are considered integral to the process as they provide a basis for understanding why change occurs and may also be used to predict possible effects of different strategies. The review, however, indicated models often only addressed the ecological aspects, and that integrated models incorporating wider social and economic considerations and decision alternatives were rare. There were many examples of passive adaptive management, focussed on a single policy, with few good examples of an active approach. Monitoring and evaluation are required to determine which option performs best, and many monitoring frameworks had been developed for specific areas, ranging from those with simple data collection to those with sophisticated statistical methods. The central theme of adaptive management is to reduce uncertainty through learning and this requires mechanisms for incorporating new information into future decisions. As active adaptive management could be seen as environmental experimentation, it is therefore important that decision makers keep stakeholders informed (Linkov et al., 2006 p. 1081).

Although decision-making requires consideration of the environmental, ecological, technological, economic and socio-political factors, relevant to evaluating and selecting management alternatives, more often decisions were driven by just one aspect of the problem. As well, quantitative tools and methods for implementing adaptive management strategies are not systemised, and no framework is available for the integration and organisation of people, processes, and tools required to make a structured and defensible environmental management decision. A general decision framework proposed by Linkov et al. (2006) is presented in Figure 4.6.1 below, that outlines the essential elements, and the combination of people; the decision-making process (generating management alternatives, success criteria, and value judgements; and ranking alternatives by applying value weights); and tools which are essential elements of the overall decision process. The integration of decision tools and scientific tools allows each a role in the decision process, without applying either type of tool beyond its intended scope. It is assumed that the framework is iterative at each phase and can be cycled through many times in complex decision-making circumstance, with each iteration giving an indication of additional details which would benefit the overall decision process. Solid lines represent direct involvement for people or utilisation of tools; dashed lines represent less direct involvement or utilisation (Linkov et al., 2006 pp. 1087-1088).

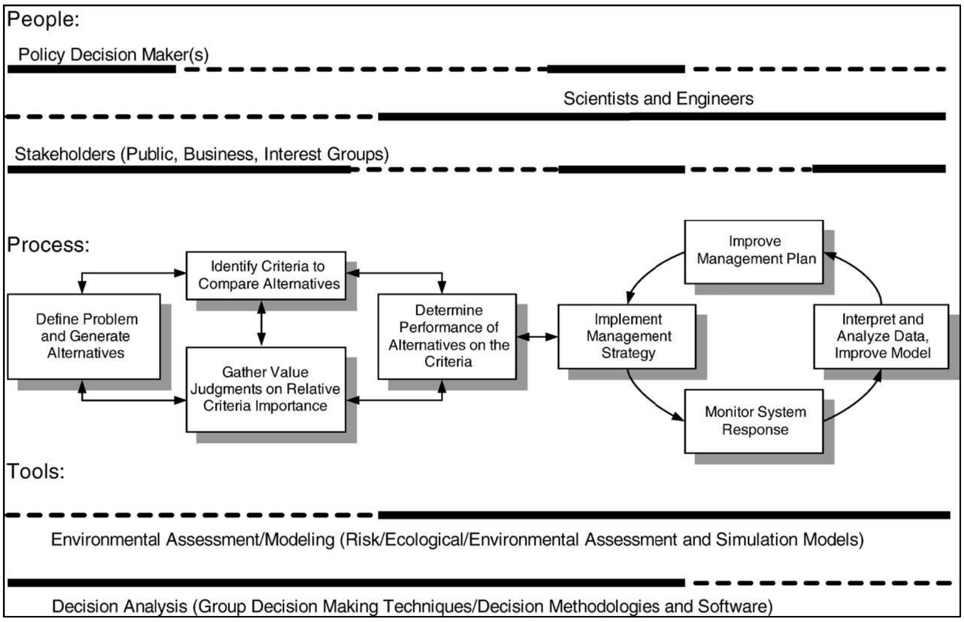


Figure 4.6.1: Adaptive decision framework (after Linkov et al., 2006, p. 1088).

4.6.2 Evaluation

According to Bellamy et al. (2001) adaptation and learning require different approaches to evaluation to enable improvements in the governance and management initiatives that contribute to sustainable resource use. Integrated program evaluation and policy analysis are critical elements of successful policy development and implementation. In theory evaluation is fundamental to identifying change; supporting an adaptive approach; and enabling progressive learning, but in practice it is often a neglected element. Natural resource management needs to be evaluated as a system that links the objectives and instrumental rationale of the policy or program to actual performance. Evaluation against a single criterion or limited set of criteria may miss important aspects. Establishment of an evaluation framework which includes the perception and views of stakeholders according to their functions can be problematic. A reporting structure is important for reporting on evaluation outcomes.

Bellamy et al. (2001) also outlined some of the reasons for undertaking evaluation. These include improving program management; incorporating transparency and accountability; reducing risk and uncertainty; fostering learning; and improving process. The evaluation methods need to be made explicit as the choice of methods for evaluation of performance measures/criteria; and the interpretation or analysis of findings will be influenced by these considerations, as will the timing of evaluation. Evaluation can be undertaken prior to implementation (ex-ante); during implementation (progress); and after completion (post-ante). A systems based evaluation framework can provide a basis for integrated evaluation of the different perspectives (social, economic, environments, institutional, and technological) on the performance of the management initiative and a rigorous basis for synthesising the findings. A structured approach is particularly important when applying adaptive management so that initiatives are not discarded or changes made without a comprehensive evaluation and assessment.

4.7 Governance and management subsystems model

As discussed by Kotchen and Young (2007) models and methods are needed that are capable of providing an understanding and insights into coupled ecosystems and human systems, and their interactions and drivers. It is also important to consider the role of governance and management systems as institutional filters, mediating between human system activities and ecosystems. Garcia and Charles (2008) argue fishery systems are a network of subsystems and it is the configuration of the ecosystem and human system dimensions and components, and the interconnecting processes and fluxes of energy and information that are responsible for the systems characteristics, performance, resilience and sustainability. All fishery systems are part of higher level ecosystems and human systems, and are difficult to understand and forecast, and this is a complicating factor for governance and management. In theory, managing human activities (the principle objective of fisheries management) are more controllable, providing adequate institutions are in place, but social behaviour remains a complex source of uncertainty. A systems representation requires decisions regarding external and internal system boundaries (scope); components (structure), scales (grain), and linkages (functions) between components. With a more comprehensive representation of a fisheries system, the number of linkages is likely to increase exponentially. Simple fishery models have usually been assumed to be generally applicable. Although more sophisticated models are required to address complex questions, these may have limited application across fisheries. Integration within fisheries should be understood as a process of developing or enhancing the interface between all the components.

On the basis of the preceding discussions (and as discussed in detail by the following authors Charles (2001); Folke et al. (2000); Westley et al. (2002); Garcia and Charles (2007). The governance and management subsystems of the model, have been further developed as per Figure 4.7 below. A set of governance (political, policy and planning, legal) and management (strategic and operational) frameworks, was also developed, which underpin the governance and management model. These provide an understanding of the respective roles and responsibilities of governance and management as were presented in section 4.2.2 in tables 4.2.2 a, b, c, d above.

The governance and management subsystems highlight the multi-level jurisdictional authority and multi-level participatory decision-making forums; and multiple institutions and stakeholders, which operate at a range of different spatial and temporal scales. The governance and management dimensions have an inferred internal hierarchy, in terms of each level setting the requirements and parameters for subsequent levels from global to local. However, in a well designed system, opportunities for management feedback and identifying issues for governances are captured within the system, thus providing top down and bottom up mechanisms for input into governance and management decision-making forums at all levels. The governance and management dynamics within each dimension, the relationships and the interdependencies between them, and the different scales at which they operate, requires mechanisms for co-ordination, co-operation and collaboration; and high level communication and sharing of relevant and timely data and information.

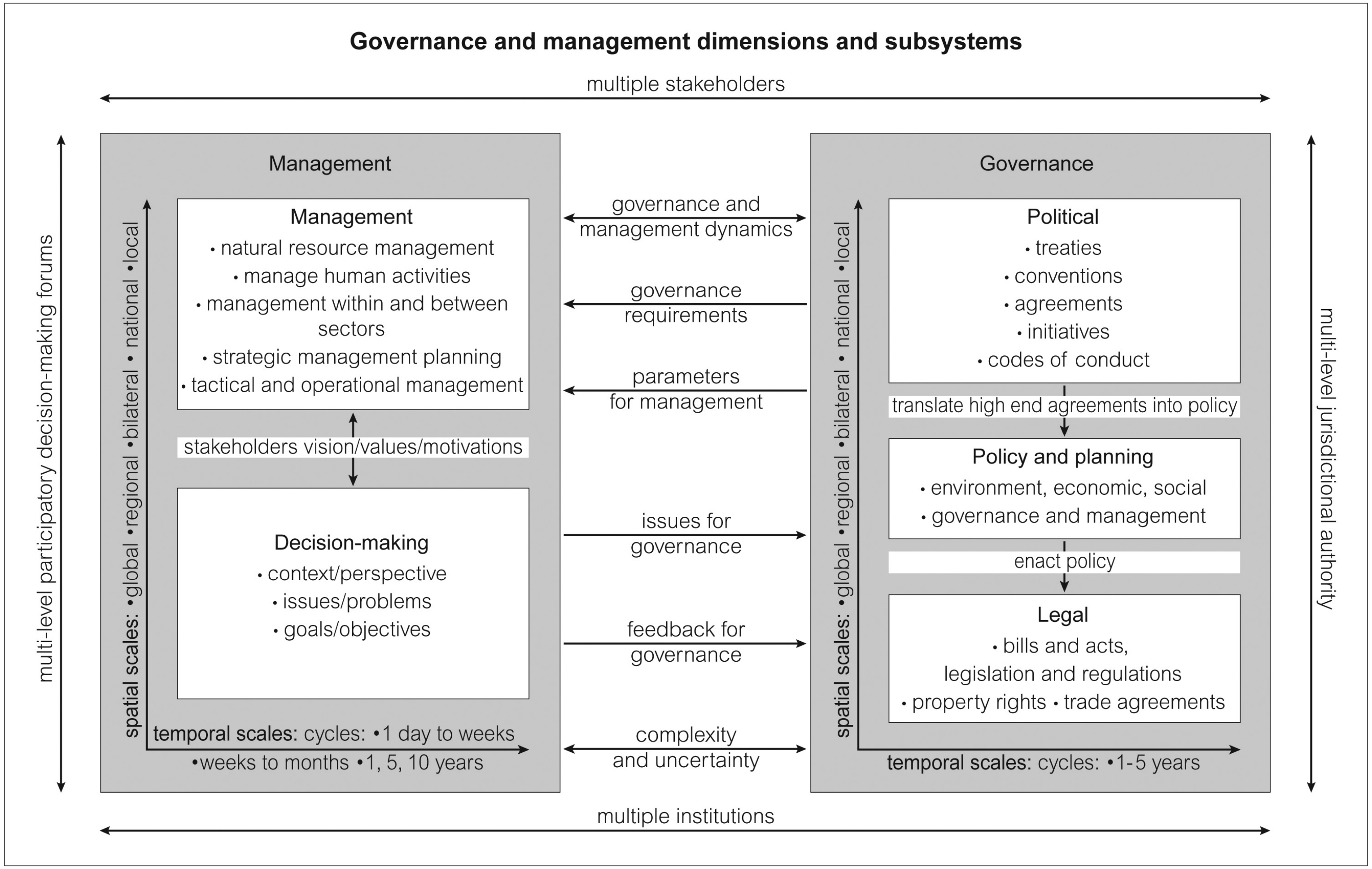


Figure 4.7: Governance and management dimensions and subsystems model.

4.8 Summary

The changing world view in response to the oceans and fisheries issues, has necessitated a different approach to governance and management arrangements at international, regional, national and local levels. Changing environmental, economic and social conditions will also require continued innovation by governance and management in response to new issues. Human activities may impact ecosystems, which in turn may respond in unexpected ways, producing surprises and undesirable outcomes for human systems. Fisheries provide a variety of economic and social benefits. The dynamic nature within and between ecosystems and human systems need to be considered by governance and management, and sustainability depends on understanding how human systems and their institutions interact. The complex relationships and responses and inherent uncertainty within and between ecosystems and human systems requires an integrated response from governance and management in balancing the conservation and use of marine resources.

The international instruments, agreements and the introduction of EBFM has resulted in a multi-level and a multi-institutional and stakeholder governance and management decision-making framework. At the international level issues relating to the high seas require co-operation and co-ordination between nations. At the regional level these relate to issues not contained with nation states EEZs, such as those of straddling stocks and highly migratory species, which may be managed through Regional Fisheries Management Organisations. At the national level each nation is subject to different environmental, economic and social conditions and issues. As discussed, nation states will be required to respond to international and regional imperatives as well as national concerns. Nationally, many of the principal issues for the marine environment are related to coastal development, with major impacts occurring at the land and marine interface. National governance and management arrangements will need to deal with these issues and with the direct and indirect impacts of fishing to maintain sustainable fisheries, as well as considering the economic and social factors and drivers.

Governance institutions are responsible for developing policy and initiatives and management actions in response to the issues and provide a framework for stakeholder interactions. The structure and function of governance and management institutions are also complex systems as they exhibit dynamic relationships and interlinkages within and between them and operate at different spatial and temporal scales. These dimensions are multi-faceted in terms of their components, characteristics and drivers. All these dimensions need to be considered in meeting societal goals and objectives and avoiding governance and management system failures. Despite the inherent complexity and uncertainty an integrated systems approach can still be undertaken which supports the development of effective governance and management arrangements, and will also facilitate the implementation of EBFM.

The governance and management subsystems model as developed in this chapter provided an understanding of the changing governance and management roles and responsibilities under EBFM principles, together with the development of multi-level jurisdictional authority and participatory decision-making forums; and the multiple institutions and stakeholders involved in oceans and fisheries governance and management. Governance and management institutions are responsible for developing integrated policy initiatives, and comprehensive management responses to environmental and human issues. These governance and management institutions are also complex systems which exhibit dynamic relationships and interlinkages that operate at different spatial and temporal scales; and are multi-faceted in terms of their components, characteristics and drivers. Under these conditions issues of institutional interplay and fit may occur. All these dimension need to be considered in meeting societal goals and objectives and avoiding governance and management system failures. Despite the inherent complexity and uncertainty an integrated systems approach can be undertaken which supports the development of effective governance and management arrangements, and facilitate adaptive management approaches.

According to (Thorne-Miller and Catena, 1991) there are three important aspects to be considered when moving towards meeting sustainability principles and objectives. First, international and national policies, laws and regulations need to be adequate, second, once adequate policies are in place these need to be effectively implemented (both these have been considered here). Third, an effective and efficient management framework is required for implementation (Thorne-Miller and Catena, 1991 p. 127). This is the subject of the Chapter 5, which considers the implementation of strategic and operational management for oceans and fisheries under EBFM principles.

CHAPTER 5: IMPLEMENTATION OF EBFM: FISHERIES STRATEGIC AND OPERATIONAL MANAGEMENT

5.1 Introduction

International instruments and agreements provide an organising framework for the implementation of Ecosystem Based Fisheries Management (EBFM) at the regional, bilateral and national level. The range of international policy initiatives and tools, developed over the last 20 years has become more sophisticated and diversified (FAO, 2003). Effective fisheries management is based on the achievement of societal goals and objectives through appropriate policy and regulatory instruments. In western developed countries fishery sectors are generally managed through government agencies. These institutions and the fishery managers are responsible for facilitating interactions among fishery participants, and in consultation with stakeholders, developing and implementing the actions necessary to achieve the policy goals, which in turn shape the strategic management arrangements and operational approaches (Charles, 2001). The scope of management should include the long-term vision and objectives for the fishery. Often short-term objectives are, however, chosen in response to immediate pressures. Such decisions may have negative effects on the whole fishery by emphasising some aspects of a fishery to the detriment of the others (Hanna, 1999).

The purpose of this Chapter is to identify the key elements considered necessary for fisheries management and the implementation of EBFM. These include stakeholder participation (already discussed in Chapter 4); applying the precautionary approach; clearly setting defined goals and objectives and reference points; developing strategic management options and arrangements; and identifying sutable operational management processes and measures. Included for discussion are fishery management plans; management harvest strategies and allocation of user rights, such as Individual Transferable Quotas (ITQs); spatial and temporal management; compliance and enforcement; and performance assessment and reporting. Research and data underpin all aspects of EBFM and is necessary for informed decision-making. The management and decision-making subsystems (of the integrated systems model under EBFM principles as introduced in Chapter 2, highlighted in Figure 5.1 below) will be further developed.

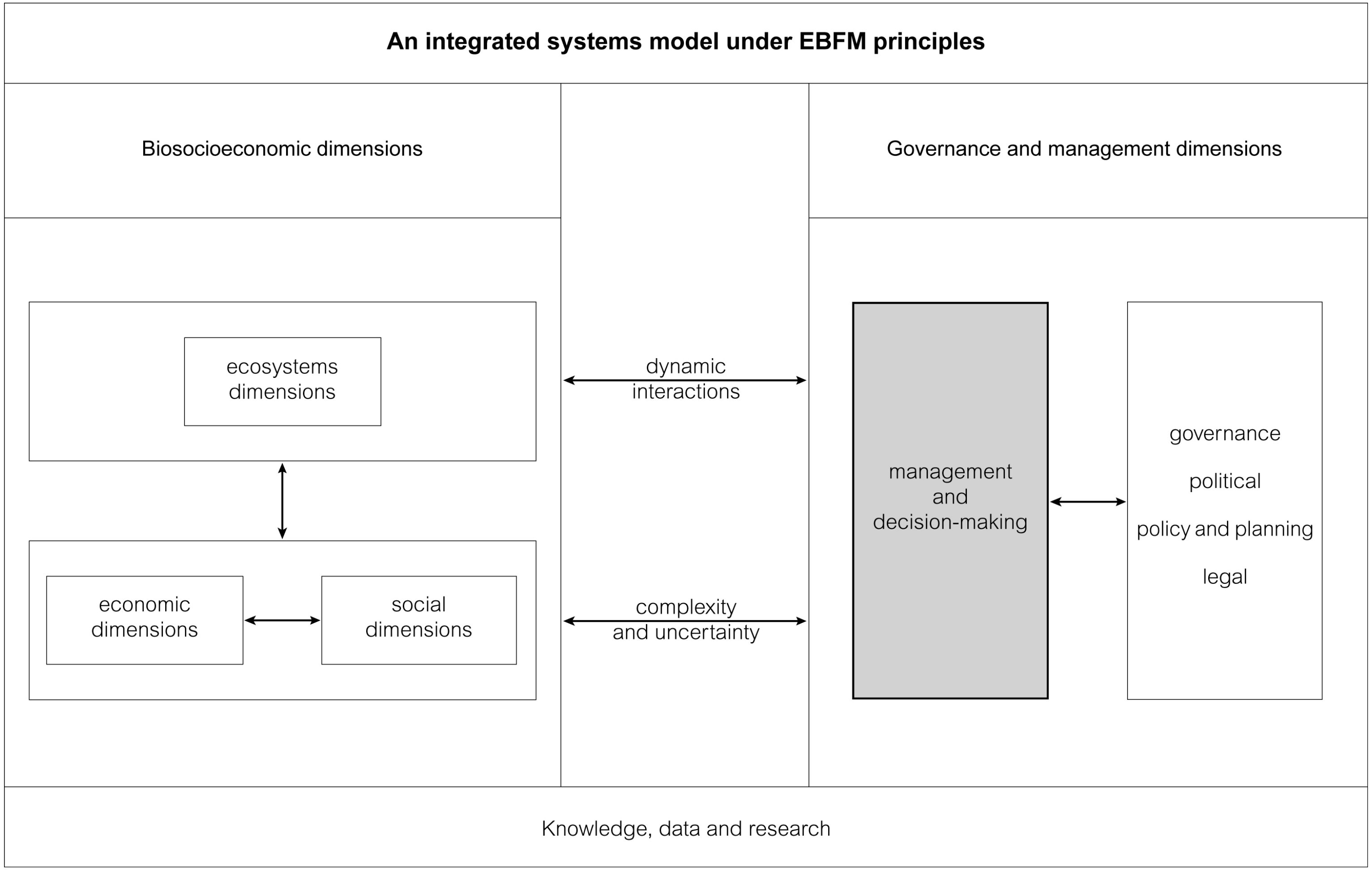


Figure 5.1: An integrated systems model under EBFM principles.

5.2 EBFM implementation: some key considerations

A number of steps have been recommended for the implementation of EBFM. The literature discusses and highlights the elements considered important for good fisheries management and the implementation of EBFM. Two of these are applying the precautionary approach; and defining goals, clearly stating objectives, developing indicators and reference points.

5.2.1 Steps for EBFM implementation

Murawski (2007 p. 685) outlined a set of principles and processes for operational implementation of EBFM, which include setting high level policy goals; identifying the broad objectives; prioritising issues to be addressed by management; setting operational objectives; developing indicators and reference points; developing decision rules for application of measures; implementation; monitoring; and evaluating performance. An analysis of the key literature (Brussard et al., 1998; de la Mare, 2005; FAO, 2003; Ecosystem Principles Advisory Panel, 1999; Sissenwine and Mace, 2003; Ward et al., 2002) reiterated the point that there were many different approaches and suggested steps considered necessary for the implementation of EBFM. A stepped approach can be useful as a check list when scoping an approach for implementing EBFM. From the literature I have summarised the steps considered important for implementation of EBFM, as listed below:

1. Identify current human activities that are taking place, and relevant historical activities.
2. Define the scale (spatial and temporal) at which these human activities are taking place, and identify any associated ecosystems impacts.
3. Identify the management issues associated with these human activities.
4. Identify all stakeholders who have an interest in these activities, and acknowledge and consider their different values and views.
5. Define and agree upon the ecosystem goals, principles, and policies, and identify and clearly state the objectives required to implement the goals (the actions).

6. Obtain all relevant ecosystem and human system data and key documents required for each of the above steps, identify knowledge gaps, and plan research to fill gaps.
7. Assess and evaluate what is already in place (governance and management).
8. Identify the appropriate goals and objectives for political, policy and planning and legal requirements, to facilitate and support implementation.
9. Assess ecological and human risk factors.
10. Plan implementation actions and in some cases a process of prioritising may be necessary and/or a staged approach (short, medium and long-term).
11. Identify the management approaches, processes and measures necessary for implementation.
12. Develop capability and capacity building such as funding, infrastructure, education and training.
13. Implement the plan.
14. Assess performance (monitoring and evaluation) and reporting.

Review a formal process (Brussard et al., 1998; de la Mare, 2005; FAO, 2003; Ecosystem Principles Advisory Panel, 1999; Sissenwine and Mace, 2003; Ward et al., 2002).

An incremental approach

The evolution of EBFM is moving at an uneven pace – driven by incremental development of governance and management arrangements, in scientific understanding, and the development of tools and methods for implementation. According to Murawski (2007) a recurring theme in developing the principles for EBFM was whether progress can or should be made in incremental, versus transformational, steps. Incremental evolution allows existing institutions to adapt and to take on broader multi-sectoral issues over a more realistic timeframe. Korn et al. (2003 p. 24) have also considered whether there is enough flexibility in the EBFM approach to apply some principles now and add others later, arguing that a stepwise approach would be useful. As FAO (2003 p. 14) point out, EBFM is not inconsistent with, nor does it replace, current fisheries management approaches, but is likely to be adopted incrementally, building on current practices. The issue of the relationship of EBFM to existing approaches was also raised by Ward et al. (2002), who suggested that a major challenge would be in establishing mechanisms for integrating and rationalising existing measures. There are many measures and instruments in place that support some of the EBFM principles, but none were considered sufficient on their own. A number of EBFM measures have been implemented; these have often been initiated in reaction to problems created by a failure to achieve sustainable fishing practices. Ward et al. (2002 p.28) suggested that it would be possible to reduce or minimise many of these measures if fisheries were managed using comprehensive EBFM principles.

Marasco et al. (2007) also suggested that EBFM is neither inconsistent nor a replacement for current fisheries management, and the move to EBFM will be incremental. During the transition the management system may look similar to current systems. In moving to EBFM it will be important to identify the respective influences, processes and interactions between the different ecosystem and human system dimensions. The move towards EBFM will take time to implement, test and adapt and will be an iterative process. McFadden and Barnes (2009) as part of a study which examined the implementation of an ecosystem approach to management identified three of the most frequently cited success strategies: encouraging collaborations; utilising multi-disciplinary approaches; and identifying common priorities.

5.2.2 The precautionary approach and how is this to be applied?

Principle 15 of the, Rio Declaration (United Nations Conference on Environment and Development, 1992) states “the precautionary approach should be widely applied and that, where there are threats of serious irreversible damage, lack of full scientific certainty should not be used as a reason for postponing cost effective measures to prevent environmental degradation”. The precautionary approach has been incorporated into a number of international agreements, including the Convention on Biological Diversity, Cartagena Protocol on Biosafety, and the International Wildlife Trade and Convention on International Trade in Endangered Species (CITES). Those instruments and agreements related specifically to oceans and fisheries management include the UN Fish Stocks Agreement, which was the first global agreement requiring a precautionary approach to fisheries management. This is to be achieved by establishing obligations for signatory states for management within nation state waters, for straddling, or highly migratory stocks and of the high seas (outlined in Article 6 and Annex II). This precautionary approach has been adopted by the Food and Agriculture Organisation of the United Nations (FAO) in the Code of Conduct for Responsible Fisheries, and supported by the FAO Technical Guidelines on the precautionary approach. Few nation states have specific legislation but some have broad legislation incorporating the precautionary approach (Fenichel et al., 2008; Cooney, 2004). A regional example is the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) which adopted management measures that conform to the intent of the precautionary approach, however there are some problems with regard to implementation and enforcement of its conservations measures, particularly with respect to the regulation and control of the expansion of new fishing activities within the Convention area (Parkes, 2000), see Box 4.3.1, Chapter 4.

The motivation towards applying the precautionary approach was an outcome of fisheries practice, of taking risk prone management decisions in the face of uncertainty, often leading to over-fished stocks. The precautionary approach calls for risk management decisions that err towards conservation. Fisheries management should change from restricting a fishing activity after is has caused an unacceptable impact, to only allowing an activity to occur if it can be demonstrated that it is not likely to cause an unacceptable impact, thus changing the burden of proof (Ecosystem Principles Advisory Panel, 1999; FAO, 2003; Sissenwine and Mace, 2003; Ward et al., 2002; Charles, 2001). The precautionary approach requires wider application than just environmental and fish resource considerations. Management objectives should relate to the environmental, and include the social and economic, in terms of long-term sustainable fisheries that provide jobs, economic opportunities, food and stable communities, and consider intergenerational equity (Hilborn et al., 2001). Ward et al. (2002 p. 14) agree with the above view but suggest that fisheries requires more than a set of cautious decisions. A comprehensive precautionary approach relies on policy that has been set to be explicitly precautionary, and which fully considers and incorporates uncertainty.

Although there have been debates regarding precautionary management and EBFM, there is little guidance on how to apply and implement it, or integrate these two ideas together in fisheries management (Sanchirico et al., 2008). Implementation will vary according to the sector concerned; the nature and source of the risks; and existing management practices and approaches. As discussed by Gonzalez-Laxe (2005) the main objective of applying the precautionary approach is to prevent resource degradation, and the consideration of opportunities for current and future generations. The management strategies to achieve this include reference points that warn of risk; decision rules regarding measures to be adopted, when reference points are approached or reached; and consideration of the economic and social consequences of the measures to be applied. As outlined by Essington (2001) policy makers are responding by shifting towards fishery management systems based on the precautionary approach. According to Hilborn et al. (2001) a precautionary system requires data collection; evaluation of results from past management; response mechanisms to adjust management actions as needed; effective enforcement of regulations; and the facilitation of communication and co-operation between different sectors. This approach to a precautionary system would be more consistent with the FAO precautionary approach.

Cooney (2004) examined the translation of the precautionary approach into operational measures, and the issues of sustainable development. A summary of the key points are as follows. The precautionary approach provides guidance for governance and management in responding to uncertainty. In the absence of scientific certainty it provides for action to avert risks of serious irreversible harm to the environment or human health. It is seen as an integral principle within sustainable development, and with regard to equity between current and future generations. Precaution is seen as shifting the balance in decision-making towards prudent foresight, in favour of monitoring, preventing or mitigating uncertain potential threats, and the notion of shifting the burden of proof and the polluter pays principle. Under some circumstances the possible outcome and likelihood of risks is well understood and the principle of prevention is relevant. In contrast where there is uncertainty with regard to outcomes and likelihood of occurrence, precaution is the relevant principle (Cooney, 2004 pp. 1-9).

Gonzalez-Laxe (2005) argued that the notion of precaution is a tool to deal with uncertainty, and as discussed in Chapter 4, there are many kinds of uncertainty. Cooney (2004) considers two other types of uncertainty, epistemic deriving from missing, inadequate or incomplete data, which may be solved by more investigation and data. The other is ontological or variability deriving from the characteristics of the system, such as complexity, scales, stochasticity, dynamics, and surprises, that can make understanding and prediction of outcomes unreliable. There may be multiple risks which arise from different sources over different timescales, all requiring consideration (Cooney, 2004 pp. 25-29). There are a number of policy processes and management tools that are linked with the precautionary approach. Policy processes include incorporation of the broader socio-economic and political factors; and reversal of evidentiary burden by placing the burden of proof on the proponent, and requiring high standards of proof. Management tools include adaptive management; environmental impact assessment; risk assessment; prohibition of particular activities; and information and monitoring requirements (Fenichel et al., 2008; Cooney, 2004 pp. 29-30).

Context will be a factor in the stated policy objectives and the decision-making forum, therefore the precautionary approach may take different forms in each, and there may be inconsistencies in application between different sectors. Applying the precautionary approach involves value judgements and trade-offs between competing management objectives and stakeholder values, priorities and objectives (Cooney, 2004 pp. 25-29, 36-39). Harding (1998) also argued that a key issue in applying the precautionary approach is one of judgement when deciding the extent and nature of the uncertainty, and determining whether there is a threat or risk of serious or irreversible environmental damage. Risk analysis involves estimating the level of risk, whereas risk assessment is concerned with the significance and acceptability of these probabilities and consequences, and this is a question for societal choice and decision-making. As discussed by Fenichel et al. (2008) the perception of risk can affect decision-making and outcomes, and are conditional on both uncertainty and management decisions. Therefore risk assessment and risk management should be applied together, because decisions affect the likelihood and the consequence of events.

5.2.3 Management objectives, indicators and reference points

The EBFM approach takes a more comprehensive approach to managing marine resources by including a wider range of ecosystem and human system components, which will also require defining a wider range of goals and objectives. As Cochrane (2002) outlines, goals are an important first step in providing both guidance and highlighting conflicting goals, or those needing to be prioritised. Goals in themselves are, however too general for implementation and require the development of operational objectives, which precisely outline the agreed objectives and what is to be achieved (outcomes). A management strategy can then be developed, using a suite of different management measures, for achieving the operational objectives. Appropriate reference points and indicators may be developed for each operational objective to measure and monitor outcomes against stated objectives, and agreed decision rules put in place should the management strategy not be successfully met (Cochrane, 2002 pp. 96-97).

Defining goals and clearly stating objectives

According to Hilborn (2007) there are four major categories of fisheries objectives: these are biological, economic, social and political. The biological objective commonly found in legislation and international agreements is maximisation of biological production, but more recently also includes protection of non-target species and ecosystems. Economic objectives usually consider economic efficiency or economic rent. The social objectives are often employment and income related, including food security, and maintenance of traditional fishing communities. Political objectives aim to avoid conflict. Stakeholders in fisheries also have a range of objectives. Until fisheries objectives are clarified it is hard to define what is meant by success in management, and learning from experience will be limited to cases where objectives, can or have been agreed to. As Dankel and Skagen (2008) highlight, the multiple and conflicting objectives are often factors that can affect fisheries management performance.

Defining goals and clearly stating objectives has been identified as essential to good fisheries management, and for implementing EBFM. There is, however often confusion over these concepts. Goals should be broad and generally agreed upon, and often have a wide, almost ethical dimension of rightness, whereas objectives are the specific tasks needed to achieve goals. The goal of sustainability although a well used term, is interpreted differently. Therefore goals should be clearly identified, have general criteria, and be context specific. At the macro level goals need to be linked to values and ethics, but at the micro level goals need to be linked to what people value in a particular place at a particular time, but recognising that balancing the macro and micro goals are a challenge (Slocombe, 1998).

Important properties of objectives are: they should be clearly stated; specific and not filled with generalisations; quantifiable by some means; have a performance measure so that progress can be evaluated; and dynamic to reflect changing societal preferences and evolving ecological conditions and constraints (Lackey, 1998). Slocombe (1998) proposed a set of desirable characteristics for ecosystem management goals and objectives as follows:

1. Imply and reflect specific values and limits (normative).
2. Reflect higher values and ethical principles and rules (principled).
3. Reflect the wide range of interests, goals and objectives that exist (integrative).
4. Work with, not artificially reduce, complexity (complex).
5. Accept and recognise the inevitability of change (dynamics).
6. Synthesise a wide range of information and knowledge (trans-disciplinary).
7. Be applicable to a wide range of ecosystem types and conditions (applicable).
8. Involve actors, stakeholders, public (participatory).
9. Be explainable and implementable in a consistent way to different people and groups (understandable).
10. Be inherently tentative and evolving as conditions and knowledge change (Slocombe, 1998 p. 484).

The challenge will be bridging the gap between the high level objectives and operational management in terms of: the specific outcomes that are intended; the targets, limits and levels of acceptable change; assessing how a given management action will help or hinder the intent; identifying how success or failure can be measured and detected; and whether a balance can be achieved across objectives that span use and conservation of complex ecosystems and human systems (Sainsbury et al., 2000 pp.

731-732). An effective approach that establishes the hierarchy between high-level and operational objectives is as follows:

- principle: a high level statement (high level objective broad statement of intent);
- conceptual objective: high-level statement of what is to be attained;
- component: a major issue of relevance within a conceptual objective;
- operational objective: an objective that has a direct and practical interpretation, usually for a component;
- indicator: something that is measured and used to track an operational objective; and
- reference point: a benchmark value of an indicator, usually in relation to the operational objective (Sainsbury and Sumaila, 2003 p. 346).

Indicators

An indicator is a variable which describes one characteristic of the state of the system. Indicators may give information about the position of the system relative to particular sustainability boundaries or goals. When many indicators are used these may be presented within a framework of categories or aggregated into an index. An index is a quantitative aggregation of many indicators that can provide a simplified and multi-dimensional view of the system. Indices usually provide a static overview of the system, but if collected regularly can show trends, and highlight which factors are driving the system. Policy makers and management require timely information that demonstrates whether the system is meeting stated sustainability objectives. Sets of sustainability indicators, and aggregation of indicators into indices, are increasingly used for governance and management decision-making, and it is therefore important to understand the strengths and weaknesses, biases and scale dependencies when using them (Mayer, 2008).

According to Link et al. (2002) several metrics exist that can indicate ecosystem status independent of specific objectives. These may be at the multi-species (community); food web (trophic dynamics); aggregate (groupings of related taxa); or whole of system (ecosystem) level. Any attempt to understand the status of an ecosystem involves multiple metrics and inter-disciplinary integration, synthesis, and interpretation of these ecosystem metrics, which need to be sensitive to change, feasible to measure, and incorporate uncertainty. It takes multiple time series of metrics and associated monitoring to assess the status of a system, to interpret these metrics in any meaningful management context. As Boyd and Charles (2006) explain indicators are measures used to quantify or qualitatively describe phenomena that are not easily measured directly, but which society considers valuable to monitor over time. Indicators are used to communicate information about complex systems or phenomena; presenting results of technical analysis, for monitoring characteristics of the system such as fisheries, to inform public decisions; and for monitoring sustainable development a concept that cannot be measured directly.

The purpose of indicators is to enhance communication, transparency, effectiveness and accountability in natural resource management. Many countries have agreed to develop and report on indicators for sustainable development. At an international level indicators can help streamline inputs to global reporting, assessments, and to be able to make comparisons between countries. At a regional level, indicators can help in harmonising strategies for management of trans-boundary resources, and measuring overall health of large-scale marine ecosystems. Nationally, indicators can produce a holistic picture of the fisheries sectors and its environment. At the fishery level, indicators provide an operational tool for management in policy setting and evaluation, assessing objectives and triggering management responses (FAO, 1999 pp. 12-13).

Indicators should provide a practical and cost effective means of tracking progress towards sustainable development; predict or warn about potential problems in the future, facilitate learning by comparing performance between fisheries, and inform policy aimed at mitigating problems (FAO, 1999 p. 4). According to the FAO *Technical Guidelines for Responsible Fisheries*, the aim in setting indicators, reference points and performance measures is to provide a framework to evaluate management rules, and to assess performance of the fishery. An indicator tracks the key outcome identified in the operational objective, and when compared with agreed target and limit reference points, provides a measure on how well management is performing. The target should be the desired state of the indicator, and the limit should be an appropriate boundary. The target and limit can be quantitative or can reflect a trend (FAO, 2003 p. 55).

A key challenge to incorporating ecosystem objectives within fisheries management is to define measurable indicators and cost effective monitoring programs that relate to ecosystem objectives, as well as reference points which trigger management actions. A challenge for science is to reach consensus on indicators and reference points that will support decision-making on ocean use activities, and highlight the need to consider impacts on both the structure (biodiversity) and the function (habitat productivity) of marine ecosystems. Indicators also need to have some predictive power, and be sensitive to ecosystem change (Gislason et al., 2000 p. 470). Fishery indicators should also be able to provide information for assessing the ecological, economic and social performance of the fishery, and as an element of the management plan they should become an input for establishing, over time, new reference points and corresponding management strategies to achieve them. The use of only one or two indicators is unlikely to be effective and may require sets of indices that reflect the state of the resource, and the socio-economic aspects (Seijo and Caddy, 2000).

Ecosystem reference points

The specification and use of reference points for key management issues and objectives is regarded as the desired approach to fishery management and is recommended in a number of the international fisheries instruments. A best practice approach recognises that what is best will continuously improve with experience, and is expected to evolve over time. Reference points are the operational measurable benchmarks that identify targets to be achieved on average, limits to be avoided, or triggers to initiate specific management responses. Target reference points specify the intended state of the managed systems. Limit reference points provide operational definitions of what constitutes unacceptable outcomes. Trigger reference points are used to initiate a management response, usually through a predefined decision rule, when a measured indicator reaches the value of the trigger reference point. How reference points are applied can be important in determining the management outcomes, therefore the management intent, context and a full range of options remains crucial, and these can be expected to change over time. Sainsbury (2008) developed a set of best practice fishery reference points for target, bycatch, threatened and endangered species; habitats; and food webs as outlined in box 5.2.3 below.

Box 5.2.3: Examples of best practice reference points for ecosystem components.

Best practice reference points for commercially retained target species involves setting reference points for both biomass and fishing mortality, while fishing mortality is under more direct management control, it is biomass (and related population structure) that influences key ecological processes and functions. Limit reference points are set primarily on biological grounds to protect stock from serious, slowly reversible or irreversible fishing impacts, which include recruitment overfishing and genetic modifications. For bycatch species (species landed and then discarded, or are affected by the gear even though not landed) the limit reference point is that populations are maintained and are not excessively depleted, with the ideal reflected in the target reference point as minimal or no by-catch, with the same limit reference points applied as those of retained species. The indicator and limit reference point may not be directly measurable for all bycatch species as there is often limited information about historical fishery catches, population abundances, or the key biological and ecological properties. Under these cases proxies can be developed within a risk assessment framework that is explicit in terms of the justification for the proxies, evidence for assessment of risk, and the use of precaution to achieve the intent of the reference point, despite the uncertainties.

Threatened, endangered or protected species (TEPs) are usually recognised under legislative processes or by international agreements which determine the benchmarks or requirements that must be applied, but there are also mechanisms for identifying those species that are not legislatively based. Best practice management for these species must allow them to recover if depleted, and to remain undepleted. The TEP reference points relate to the mortality that is imposed, with the target reference point as minimal or zero fishing mortality. The limit reference points is a fishing mortality that unacceptably reduces the population or unacceptable low recovery. The best practice limit point is mortality or number of deaths calculated using the Potential Biological Removals method with recovery factor (Fr) of 0.5, or variations of that method with similar intent. This is a highly precautionary method which can be applied with limited information (life history and estimate of population size) to calculate the number of deaths that would significantly impair populations.

A habitat is the biological and physical environment in which an organism lives. Organisms often occupy different habitats at different ages so there is often a chain of critical habitats required by a species to complete its life cycle. Habitats are considered one of the basic determinants of the structure and productivity of marine ecosystems, and of the kind and amount of fishery production available. Habitats determine the carrying capacity or productivity of the target, bycatch and TEP species, and biodiversity and ecosystem processes. There is no widely agreed approach to the selection and use of reference points but there are examples of best practice emerging and simple theoretical guidance about the likely limits of habitat modification for sustainable fisheries. The best practice context for management is to identify critical habitats for species of interest and ensure such habitats are exposed to no more than minimal and temporary impacts, and if a wide enough range of species is considered this effectively becomes a no net loss requirement for the unfished habitat coverage, as all habitats are likely to be critical to one species or another. In some cases it may be appropriate or necessary to consider habitat quality rather than simply a real extent of the habitats.

Food webs provide the direct basis of fishery production and determine other attributes of marine ecosystems. Issues with regard to the effect of fisheries on food webs include impairing the size, productivity or resilience of predators (fish, birds, mammals) through removal of their prey, and destabilising or switching foods webs and related ecosystem structure to different stable states. Best practice in the management of food web interactions is not well developed. A minimal requirement in the management system is explicit recognition of the potential food web interactions, and an ability to modify fishing controls, in order to manage significant food web interactions that are considered likely. For identified key elements of the food web best practice involves explicit nomination of significant prey or forage species in fisheries management plans, and having specific management conditions and reference points for them. For food webs as a whole, current thinking is that a suite of indicators and references may be needed, including comparisons with unfished reference sites.

(Sainsbury, 2008 pp. v-xiii)

Reporting

For indicators to be a successful tool in evaluating performance and progress towards sustainability, monitoring and an adequate form of reporting is essential. Reports need to be accurate, complete, transparent and timely. It is helpful for reports to be consistent across fisheries and within jurisdictions as this allows aggregation of information at the different levels from the local to the national (FAO, 1999). Fisheries management is an interactive system and therefore it is important to report and evaluate the whole management system, not just its individual parts (Sainsbury and Sumaila, 2003 p. 345).

5.3 Strategic fishery management

Traditionally the purpose of commercial fisheries management was to ensure maximum sustainable yield of the target fish species and economically viable fisheries. Under EBFM principles the scope and purpose of fisheries management has broadened to include wider ecosystem, economic, social considerations, and management arrangements in an integrated manner. There are many possible strategic goals for fishery management, from maximising catches, employment, income supply, fishery conservation and protection of marine ecosystems. Once management objectives have been identified, management strategies can be developed, and then management actions can be implemented, to meet the stated objectives (King, 2007 pp. 284-287). As discussed in Chapter 3, fisheries operates at different spatial and temporal scales and are diverse, therefore the specific fishery goals and objectives will be context dependent. Fisheries management will need to respond to the different sector issues, and the differences between fishery sectors (Defeo et al., 2007 pp. 3-4).

Management involves consultation with stakeholders in reaching agreement on the fishery management objectives; developing responsive management arrangements; implementing effective operational management processes and measures; compliance and enforcement programs; performance and assessment reporting; and research and data management (King, 2007 pp. 285-314). These are discussed in subsequent sections of this Chapter. The following sections will focus on the key elements of fisheries management considered necessary for the implementation of EBFM.

5.3.1 Fisheries management and decision-making tools

There is a range of tools that may be used to help assist decision makers to deal with fishery issues, and the development of management arrangements. A number of these tools are already in place, for example management strategy evaluation (MSE) and risk assessment. Others are being further developed in response to EBFM requirements such as qualitative and quantitative models, and mapping tools. The fishing industry, in response to particular sector issues, may develop codes of conduct; develop and apply Environmental Management Systems (EMS); or undergo accreditation through ecolabelling schemes, such as the Marine Stewardship Council (MSC). Each of these is outlined briefly below.

Management Strategy Evaluation

Fisheries management is characterised by multiple and conflicting objectives, multiple stakeholders with divergent interests, and high levels of uncertainty about the dynamics of the resources to be managed. MSE can assist in the resolution of these issues (Smith et al., 1999). It is at the strategic and operational fishery management level that the broad policy goals are linked to management actions, and often there are choices to be made between alternative management actions. MSE is an approach that provides a formal framework for evaluating the effectiveness of alternative management strategies in achieving defined objectives. The approach is participatory and requires close collaboration between management agencies, stakeholders, and technical experts. The MSE approach involves assessing the consequences of a range of management strategies or options, and presenting the results in a way that makes explicit the trade-offs in performance across different management objectives. The approach does not seek to specify an optimal strategy or decision. Instead it aims to provide decision makers with the information on which to base a rational decision, given their particular objectives, preferences, and attitudes to risk. It deals explicitly with multiple and potentially conflicting objectives, and with scientific uncertainty. In dealing explicitly with sources of uncertainty, and in predicting the consequences of alternative management actions, it directly supports operational use of the precautionary approach (Sainsbury et al., 2000). A schematic representation of the MSE framework is presented in Figure 5.3.1 below.

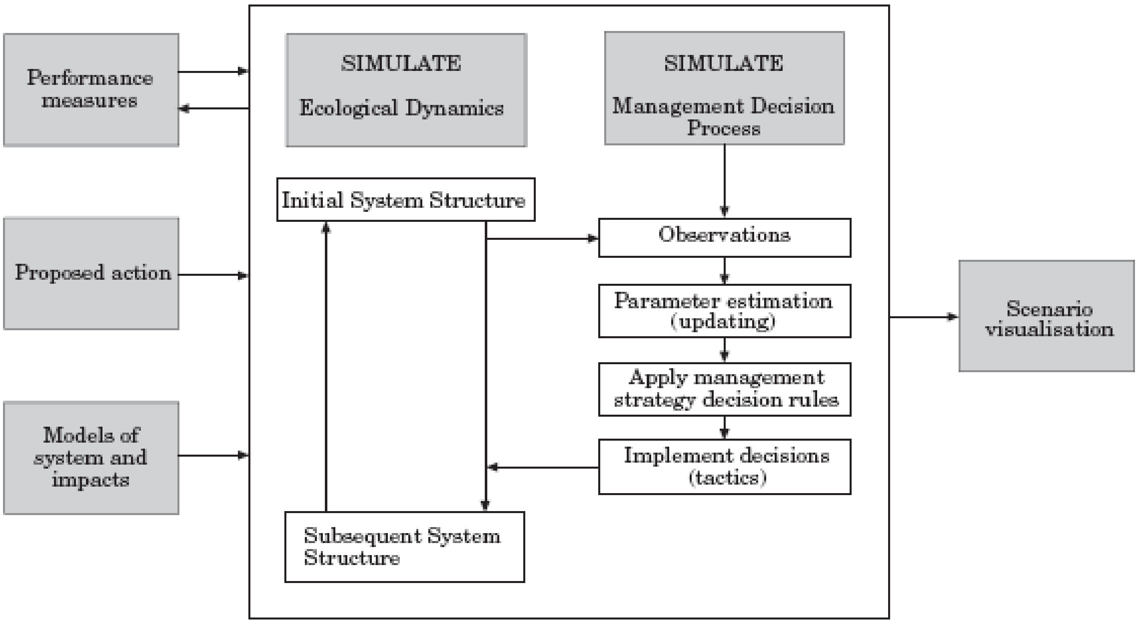


Figure 5.3.1: Framework for management strategy evaluation (source Sainsbury et al., 2000 p. 734).

MSE has been used to develop management strategies to achieve objectives relating to target species and to the ecosystem. It has also been applied to fisheries problems involving spatially based management, and should be applicable to the design and monitoring of marine protected areas. However, applying MSE to a wider range of ecosystem and resource use objectives, will involve dealing with greater levels of uncertainty and complexity than has been attempted to date (Sainsbury et al., 2000). MSE has been applied to several single and multi-species fisheries, but most have focused on yield or stock status objectives, and few have explicitly considered economics or incorporated performance measures relating to broader ecosystem dimensions. A recent study undertaken for an Australian prawn fishery has, however, demonstrated that it is possible to undertake an MSE which considers a broader set of management objectives (Dichmont et al., 2008).

Risk assessment

It is important that uncertainties and associated risks are understood and management measures are undertaken to deal with them. There is increasing understanding of the need to develop both quantitative methods to address uncertainty in fisheries, for example in terms of setting catch and fishing effort limits, as well as qualitatively in terms of approaches to fishery management. Risk assessment is a tool for analysing uncertainty, measuring risks, and predicting the outcome of different management scenarios, whereas risk management is concerned with the best course of action to take given the risks (Charles, 2001 p. 210).

According to Peterman (2004) risk has two components: the magnitudes of adverse consequences that can result from uncertain events and the probability of these events and their consequences occurring. Risk assessment refers to the general process of estimating both components of risk. As discussed by Burgman (2005) risk is the chance, within a specified time frame, of an adverse event with specific consequences. Risk assessments are used to make decisions about current activities and their associated uncertain future outcomes. It is important to evaluate and communicate the extent and nature of uncertainty in relationship to the activities and the risks these pose. Judgement about risks may be underestimated or ignored, depending on societal choice, based on particular values at a particular time (Burgman, 2005 pp. 1-6).

The concepts of probability influences risk measurement, interpretation and communication. Probability can be viewed as the statistical frequency (or relative frequency) with which an event is expected to occur, and it can be viewed as the degree of belief warranted by evidence. However, given the range of words used to indicate probability in terms of what is known, perceived or believed about processes or outcomes, it is therefore important to be clear about the use and interpretation of such words, and the evaluations and conclusions that may be drawn (Burgman, 2005 pp. 8-10). An environmental risk management cycle include, problem formulation; hazard identification; risk analysis; sensitivity analysis; decision-making; monitoring; and communication and review. It is viewed as a learning process, and as new information becomes available this allows for improved understanding and decision-making over time (Burgman, 2005 pp. 54-55).

Generally a risk assessment in fisheries includes five components: management objectives and indicators to measure the objectives; management options for achieving the objectives; a stochastic model of the systems processes; quantified hypotheses-parameter values, relationships between variables; and, uncertainties are taken into account by weighting of hypotheses and their consequences. It is not sufficient for decision makers to just describe and quantify uncertainties and risk, it is important to know how these might affect management outcomes in meeting agreed management objectives. A decision analysis allows for this process through decision tables which structures the analysis and communicates its contents; ranks management options; and provides a sensitivity analyses. Risk management is the process by which decision makers consider the factors, make trade-offs, and manage the risks in selecting particular management actions (Peterman, 2004).

Quantitative ecological risk assessments, generally, use mathematical models to describe the relationships between the component parts, but this method is only possible in data rich fisheries. Qualitative ecological risk assessments use a combination of attributes, where the information is at a general level, and this method is used in data deficient fisheries. A qualitative risk assessment is not necessarily less reliable than a quantitative approach. The difficulty for both quantitative and qualitative ecological risk assessment methods is that the marine ecosystems to which they are applied are complex (Astles et al., 2006). In Australia a number of different approaches (qualitative, semi quantitative) to risk assessment have been developed, but currently mainly focus on the ecological dimensions. These will be discussed in Part Two of the thesis.

Qualitative and quantitative models

Modelling is considered an essential scientific tool for developing ecosystem approaches for fishery management. Modelling can be used as a tool for assessing policy development, integrated management, and aid decision-making (Charles, 2001 pp. 246-249). Modelling can also be used to understand the past, which is particularly valuable in assessing past management practices and thus providing a learning environment; and to predict future outcomes from proposed management actions (Ecosystem Principles Advisory Panel, 1999). Models may be qualitative or quantitative. Models have the potential to provide managers with information about how ecosystems are likely to respond to changes in fishery management practices. As with MSE, ecosystem models under EBFM principles will be more complex than traditional models. Integrated models focus on the need to understand the complex interrelationships among the components of the fishery. A wide variety of modelling approaches has been developed to provide advice to fisheries managers regarding outcomes of proposed alternative management actions and to improve the design of fishery management systems (McAllister et al., 1999).

Stefansson (2003) considers that many important management questions can only be addressed by the use of complex models, and tools such as these are needed to evaluate ecosystems in a more comprehensive manner. An important result from modelling is the potential to be able to view the system and fisheries as a whole. To do this requires extensive data, some of which may not be available, but highlights what data is needed to be able to predict the effects of particular management measures, or to be able to provide management advice. In cases where data is missing, if management is to be in accordance with the precautionary approach, management measures will need to be implemented to deal with such uncertainty. If the necessary data is available providing the ability to predict outcomes of proposed actions, therefore reducing uncertainty, it may then be possible reduce or relax some management measures (Stefansson, 2003 pp. 171-186).

As Curry et al. (2008) discuss, ecosystems models aim at developing realistic and robust models representing the systems dimensions and components at different levels of organisation; the dynamic interactions and relationships; analysis of top down and bottom up controls; short-term and long-term predictive capability; and to address specific questions. Technological advances, model design, and data collection make it possible to study problems at the ecosystem level however a balanced research strategy is needed to avoid overly complex models which may be of limited use. To support EBFM marine ecosystem modelling requires integrating the physical and biological processes at different scales, implementing feedback between ecosystem components; and taking into account the dynamic forcing effect of climate change and human system activities at different spatial and temporal scales. One such approach is the coupling of existing models, the so called end-to-end modelling. The advantages of this approach are that it can be time and cost effective, however it may require resolving the different structures and spatio-temporal resolution of the existing models.

Attempts have been made to quantify multiple objectives and include these in bio-economic modelling and analysis of fisheries management options. Outcomes can be identified which best achieve the set of objectives as a whole however these may be sub-optimal with respect to any single objective. Assessing spatial fisheries management options introduces additional complexities as spatial management has differing impacts, depending where and how the action is applied. Bio-economic models that include spatial elements of the fleet, stock and ecological dynamics necessary for analysis, require detailed information which is often not available. The inclusion of the social aspects introduces further complications and is often excluded even in non-spatial models (Pascoe et al., 2009). The utility and quality of models can be tested against real world applications, and based on the criteria of testability, repeatability, predictability and simplicity. If more complex or detailed questions are asked the model will also need be more complex and detailed. In Australia an alternative Management Strategies Project was set up to explore scenarios for improved management of the Southern and Eastern Scalefish and Shark Fishery (SESSF). The aim was to focus on integrated management solutions (i.e. using a co-ordinated combination of management tools), with impacts on the ecology and all aspects of the fishery, and on all sectors being considered simultaneously. Evaluation of scenarios under Stage one used qualitative methods and expert judgement, whereas Stage two used qualitative and quantitative methods including modelling (Fulton et al., 2007; Smith et al., 2004).

Mapping tools

There are many ways of depicting fisheries information graphically and this approach often makes presentation of the facts or issues very clear to stakeholders (Charles, 2001). Mapping of spatial information is now possible with the application of computer based geographical information systems (GIS) that can summarise ecosystem and human systems data, based on a range of information sources. These maps can, for example, provide a snapshot of the geographical boundary of an ecosystem; together with the spatial distribution of habitat and fish species; and fishing effort and management jurisdictions. This snapshot can then provide a basis for future evaluation comparisons. A more complicated map may also overlay other marine users showing where there might be potential for conflict between users and/or high stress on a particular area of an ecosystem. The information presented in this manner can also be used for decision-making purposes, such as zoning (Pauly et al., 2003 pp. 87-100).

Babcock et al. (2005) argued that terrestrial mapping and spatial analysis is more advanced and sophisticated than for the marine environment. Reasons for this are that the marine environment is more complex, as the ocean is three dimensional and developing spatial marine GIS databases are more labour and data intensive. From an EBFM perspective referenced data and mapping of habitat, resource distribution and fishing effort make it possible, in principle, to derive spatial indicators of fishing impact, and examine a range of other ecosystems, economic and social questions about fisheries. In Australia new technologies such as vessel monitoring systems (VMS) and the development of inexpensive GIS software also allows development of geo-referenced data analyses, which are potentially useful for deriving observational indicators; providing inputs for example, single and mutli-species models; and for improving fishery management.

5.3.2 Industry based initiatives

Codes of conduct and codes of practice

The introduction of the FAO Code of Conduct for Responsible Fisheries states "This Code sets out principles and international standards of behaviour for responsible practices, with a view to ensuring the effective conservation, management and development of living aquatic resources, with due respect for the ecosystem and biodiversity" (FAO, 1995 p. 1). The Code provides a benchmark for fisheries management, and addresses specific impacts of fisheries on the marine environment. Article 6 of the Code outlines the general principles. Article 7 sets out the general scope of the Code; the management objectives, framework and procedures, and measures; data gathering and management advice; application of the precautionary approach; and implementation (FAO, 1995 pp. 4-16). Some industry and marine sectors have taken the initiative by developing and adopting industry specific codes of practice. The aim of these voluntary codes is for the sector to be self-regulating rather than being regulated by government.

Environmental Management Systems

As a non-government organisation based in Switzerland, the International Organisation for Standardisation (ISO) is the most representative and influential organisation in the world for standard setting. The ISO's global network identifies what international standards business, government and society require, and these are developed through international consensus. The ISO 9000 series has become the international reference for quality management requirements in business, and the ISO 14000 and its family of standards provide guidance for environmental management systems. Within the ISO 14000 series ISO 14001 Environmental Management Systems outlines the standard requirements for the development of an environmental management system (EMS). An EMS is a documented process for the continual cycle of planning, implementation, reviewing and improving the procedures and actions that an organisation undertakes to meet its environmental goals and objectives; and is designed to lead to continual improvement of the environmental management and performance. ISO 14001 has been advocated as an effective means of managing a wide range of marine resource use activities, including fishing, aquaculture and marine ecosystems (Thompson et al., 2008 p. 728).

Other related schemes include the British standards for Environmental Management Systems (EMS) designed to improve environmental performance, it takes a systematic and integrated management approach. The European Eco-Management and Audit Scheme (EMAS) takes a more proactive approach to development and unlike the British EMS a detailed environmental statement is required for every site participating in the scheme (Morrow and Rondinelli, 2002). In Australia *The Seafood EMS Chooser* was developed by Seafood Services Australia Ltd, for the seafood industry, and is applicable to fishing, aquaculture and the post-harvest sector of the industry. This Environmental Management System (EMS) puts in place a process of planning and implementation; reviewing and continually improving the actions an organisation undertakes to manage its risks and opportunities (Seafood Services Australia Ltd, 2005).

According to Thompson et al. (2008) internationally it has been recognised that although there are guidelines and best practices, there is a lack of standards for quality management practices in Marine Protected Areas (MPAs). ISO 14001 has the flexibility and adaptability to be used as a standard in a wide variety of organisations and is applicable to a number of sectors including natural resource management. The ISO 14001 EMS has been implemented in national parks and protected areas in North America, Canada and Europe', although the scope of activities under the respective

EMS varies and these examples have primarily been applied to terrestrial parks. The application of the ISO 14001 standard could be developed and applied to Marine Protected Areas. Results from a pilot case study in Chile highlighted the potential for using ISO as the benchmark for Marine Protected Areas management. Adopting the ISO 14001 EMS standards for MPA management could help codify existing guidelines and best practices by providing essential components required for quality management; enhance communications; raise awareness and facilitate public engagement in the planning process for MPAs. The widespread use of ISO 14001 in MPA management could provide a global benchmark and an internationally recognised standard for MPA management that is auditable and certifiable.

Accreditation schemes/eco-labelling

Commercial fisheries have begun to adopt standards for certifying the sustainable management of a fishery. Eco-labelling schemes provide producers with an incentive through market share to manage fisheries sustainably, and customers with information enabling them to choose fish products that are harvested on a sustainable basis. Accreditation and eco-labelling schemes are increasingly being perceived as a method that can maintain the productivity and economic value of fisheries, as well as providing incentives for improved fisheries management and conservation of biodiversity. Eco-labels are seals of approval which endorse fisheries that comply with a set of sustainability standards or criteria, and fish products that are harvested on a sustainable basis (Ward et al., 2003 pp. 186-191). The FAO *Guidelines for the eco-labelling of fish and fishery products from marine capture fisheries*, refers to the scope, principles, general considerations, terms and definitions, minimum substantive requirements and criteria for eco-labels, and the procedural and institutional aspects (FAO, 2005 p. iv).

An example is the Marine Stewardship Council (MSC) accreditation scheme. At the centre of the MSC accreditation is a set of *Principles and Criteria for Sustainable Fishing* which is used as a standard in third party, independent and voluntary certification programs. These Principles reflect a recognition that a sustainable fishery should be based upon:

- the maintenance and re-establishment of healthy populations of targeted species;

- the maintenance of the integrity of ecosystems;
- the development and maintenance of effective fisheries management systems, taking into account all relevant biological, technological, economic, social, environmental and commercial aspects; and
- compliance with relevant local and national local laws and standards and international understandings and agreements (Marine Stewardship Council, 2002 p. 1).

The MSC is an independent, global, non-profit organisation, the role of which is to recognise, via a certification program, well-managed fisheries and to harness consumer preference for seafood products bearing the MSC label of approval. The MSC's environmental standards for sustainable fishing, and the Principles and Criteria for Sustainable Fishing, are based on the FAO Code of Conduct for Responsible Fisheries. Fisheries can apply to be independently assessed against this standard. The assessments are not undertaken by the MSC, but by independent companies judged by the MSC to be competent to assess fisheries to its standard certification, and which have been accredited by the Accreditation Services International to perform MSC assessments. This is to ensure that evaluations are unbiased, credible, transparent, and provide a rigorous assessment, for fisheries wishing to achieve certification to the MSC Standard.

If a fishery meets the MSC Standard, it is certified, and then gains the right to use the MSC logo on their products (May et al., 2003 pp. 14-21). Once certified, companies wishing to use the MSC products are subject to post certification audits and regular reassessments. Chain of Custody certification guarantees traceability of MSC labelled seafood, ensuring these products have been separated from non-certified products at every stage of the production, including primary processors, secondary processors, wholesalers, distributors, importers, retailers, food services, restaurants, or any other business that handles MSC products (Chaffee, 2003 pp. 34-35). As discussed by Ponte (2008) eco-labelled products are a small but growing segment of the fish wholesaling and retailing sector, due to increased concerns regarding sustainability and increased competition in retail markets. Prior to the MSC accreditation, voluntary labelling dealt with single issues such as dolphins in tuna fisheries, and turtles in shrimp fisheries. In these cases the main issues was protection of endangered species, not sustainability concerns such as over-fishing and over-capacity.

Ponte (2008) reported that in 2000, the MSC initiative was questioned over the actual sustainability of certified fisheries, and was criticised for failing to cater for the need of developing country fisheries, especially small-scale and data poor fisheries. Results from a commissioned study by MSC (Agnew et al., 2006) were mixed. The study examined 10 out of the 22 certified fisheries that have been subject to at least one post certification audit to determine whether they could be assessed quantitatively and whether there were environmental benefits accruing from certification. The biggest gains were for those fisheries where conditions applied to certification, and that difficult fisheries, if encouraged to apply for certification, were those most likely to create the biggest environmental gains. The MSC recognised that there were barriers and issues for developing countries in certification procedures. In response the MSC set up a special program to improve awareness of MSC and develop guidelines for assessment using a risk-based approach to qualitatively evaluate these fisheries.

5.4 Operational management

Implementation of EBFM involves a wide range of possible actions and activities, and it can be difficult to identify the key actions required to achieve the desired objectives and outcomes (Ward et al., 2002 p. 49). Mangers can apply a range of controls in terms of input and output controls, technical or regulatory measures. Another approach is to manage though incentives in ways that fishers' interests become more aligned to societal objectives, such as sustainability. This requires fishers to have a stake in the future of the fishery resources through appropriate incentives and property rights. The EBFM approach incorporates many of the best practice aspects of existing fisheries management processes and measures, and is implemented via strategies that attempt to balance (given the uncertainties) diverse objectives within ecologically sustainable boundaries (Grafton et al., 2007). A number of fishery management processes and measures considered important and recommended for the implementation EBFM included the development and implementation of Fishery Management Plans (FMPs), and a toolbox approach to management processes and measures.

5.4.1 Fisheries management plans and regulations

A fisheries management system requires a policy, strategy and an operational management plan (Garcia and Cochrane, 2005). The FAO *Technical Guidelines for Responsible Fisheries* outlines the suggested elements that should ideally be incorporated into Fishery Management Plans (FMPs), as well as the process of developing, modifying and implementing a fisheries management plan. The plan should be a formal or informal arrangement between fishery management authorities and the relevant stakeholders. The processes of developing, and modifying, fishery management plans, and the suggested elements for a fishery management, include scoping the fishery (including the broad issues and background); identifying stakeholders; setting the fishery objectives; selection of management measures and decision rules; access rights and allocations; implementation of the plan; monitoring, control and surveillance; evaluation of management and fishery performance; and scheduled reviews. Ideally the spatial coverage of the management plan would match with a clearly defined ecosystem. However, it is recognised that ecosystems do not necessarily have easily defined borders and most ecosystems span more than one management area. Stakeholder consultation and participation is critical at all stages of developing and reviewing FMPs to maintain transparency, credibility and ownership of the outcomes. Under EBFM principles a FMP will also need to recognise existing fisheries management measures, and build incrementally on these. This may require adding additional elements to existing plans and legal and institutional measures. It might also be necessary to develop a higher level plan that outlines the broad management objectives and measures to achieve them, setting out the strategic approach for the following three to five years, together with an annual operational plan which sets out operational objectives, indicators and performance measures (FAO, 2003 pp. 43-64).

Ward et al. (2002) suggest that if FMPs are properly implemented they should enable an integrated approach to fishery management; take ecosystem effects into account; and mitigate the impacts on, or protect significant habitats, non-target species, and associated and dependent species; and ensure that stakeholder concerns and legal obligations are addressed. The issue of boundaries as highlighted above is also an important element (Ward et al., 2002 p. 44). As Gislason et al. (2000) explain the geographical boundaries of marine ecosystems may be difficult to define, and may depend on the issue being addressed. The relevant oceanographic and biological features are generally large-scale and species-specific, whereas management areas of interest to the fishery are often defined at a smaller scale. There is also a need to enhance the conservation objectives of fisheries management plans to explicitly include ecosystem considerations. The Ecosystem Principles Advisory Panel (1999) suggest that FMPs should continue to be the basic tool for fisheries management, but are not sufficient for implementing an ecosystems approach and recommend Fisheries Ecosystem Plans (FEPs). FEPs need to be both substantive and realistic and should contain information about ecosystems which allow managers to make informed decisions, but the primary purpose is to prescribe how fisheries will be managed from an ecosystem perspective (Ecosystem Principles Advisory Panel, 1999 pp. 27-3.4). Sissenwine and Mace (2003) also support the notion that FEPs as a useful mechanism for implementing an ecosystem approach for responsible fisheries management.

5.4.2 Management processes and measures

There is already a wide range of specific fishery management processes and measures and tools available and in use. Under EBFM existing management processes and measures will need to be considered in a broader context in terms of addressing ecosystem as well economic and social objectives. In practice this will require choosing a range of measures, a toolbox approach, for effective fisheries management, and when implementing EBFM (FAO, 2003; Ecosystem Principles Advisory Panel, 1999; Sissenwine and Mace, 2003; Ward et al., 2002; Garcia et al., 2003). Each management instrument has particular strengths and weaknesses and no one mechanism is likely to provide the optimum solution. In practice, oceans and fisheries are managed by a combination of mechanisms. Although the benefits and application of market mechanisms are often promoted on the basis of economic efficiency, and achievement of management objectives at the least cost to the community, they also have practical limitations, and if not well designed may not meet the stated objectives (Griener et al., 1997). Regulations can often strengthen management and are often required where objectives such as resource conservation cannot be assured via market mechanisms. Regulatory instruments are used to limit the effects or impacts of activities on the resource, whereas economic or market-based instruments do not directly control or restrict activities, but create economic incentives for individuals to change their behaviour, and take into account all the costs of fishing activities. In fisheries these are often described as input controls designed to reduce fishing effort, and output controls designed to limit catch levels (Barbier, 1992). There are a number of approaches to categorising fisheries measures, and one approach is presented in table 5.4.2 below, which includes a broader range of measures that might also be used for EBFM implementation.

Table 5.4.2: Fisheries management measures.

Inputs (effort)	Outputs (catch)	Technical	Government Market	Spatial and temporal
Limited entry: licence/ fishing units Fishing permits Gear type allowed Time at sea Vessel capacity	Fish size and sex selectivity Total allowable catch (TAC)	Gear restrictions and selectivity improvements: mesh size, escapement devices VMS Minimisation of lost fishing gear	Individual transferable quotas (ITQs) Fleet reduction buy back schemes Taxes and subsidies Bonds ITE	Area closures critical life history stages Seasonal closures - spawning Critical habitat and protection Reserves and refuges MPAs Zoning

(Based on Cochrane, 2002; Griener et al., 1997; Barbier, 1992)

There is an extensive literature on fisheries management measures; discussions here will be limited to the key management processes, measures and tools that have been identified as central in implementing EBFM. These include harvest strategies and the allocation of user rights; spatial and temporal management, particularly Marine Protected Areas (MPAs); compliance and enforcement; fishery and fisheries management performance assessment and reporting requirements; and a multi-disciplinary and trans-disciplinary approach to knowledge, research and data for informed decision-making.

5.4.3 Harvest strategies and the allocation of property rights

Harvest strategies

Fisheries are a component of marine ecosystems as fish are influenced by marine ecosystems, and commercial fishing affects the targeted fish stocks, and other ecosystem components directly or indirectly (Sissenwine and Mace, 2003). Traditional fisheries management aimed to determine levels of safe removal of surplus production based on maximum sustainable yields. However, an interesting point is made with regard to fisheries within an ecosystem context, in that the rationale for harvesting surplus production is unclear, as very little biomass is truly surplus in an ecosystem under natural conditions (Ecosystem Principles Advisory Panel, 1999). Prior to the early 1950s the focus of fisheries management was maximum sustainable yield (MSY), from the early1950s to the 1970s the concept of maximum economic yield (MEY) was introduced. Since then the concept of optimum sustainable yield (OSY) has been developed requiring fisheries management to include biological, economic, financial, cultural, social, legal and political factors (Hundloe, 2002). In relation to the FAO statistics, the overall perception regarding the state of world fishery resources depends on whether MSY is viewed as a target (a conventional view of traditional fisheries management) or a limit to be avoided, the more precautionary view (Garcia and de Levia Moreno, 2003 p. 18).

According to Mace (2001) in fisheries science there is a growing consensus that MSY should be reinterpreted as an upper limit rather than a management target. The biological objective commonly found in legislation and international agreements however is MSY which, according to Hilborn (2007) has a long and controversial history within fisheries science. As outlined by Stafford (2008) within the last few decades there has been an additional emphasis on protection of non-target species and ecosystems with the introduction of EBFM. The Johannesburg Declaration sets a target for all fish stocks to be managed at MSY from 2015, implying that interactions between species need to be considered. Environmental variability that affects the productivity of fisheries resources needs to be considered when using maximum sustainable yield (MSY) as a harvest strategy.

Allocations in fisheries management

In an open access and unregulated situation a wildfish stock is a resource over which no individual has exclusive property rights. Each individual in the fishery is motivated to compete for maximum share of the resource and has little incentive to practise conservation. If demand is high in relation to fishing costs it is almost inevitable that an unmanaged fish stock will be over-exploited. Under these conditions externalities will occur, fish stocks may not be harvested on a sustainable basis, and the commercial fishing sector may incur high costs of fishing; and in the long-term the fishery may not remain economically viable. Management is therefore necessary both to protect the stock, and ensure stability of the industry (Bromely, 1991). The characteristics of common pool resources are such that the exclusion or control of access of potential users is difficult (exclusion problem), as each user is capable of subtracting from the welfare of all other users (the subtractability problem). Exclusion refers to the ability to exclude people other than the defined users, and subtractability refers to the design mechanisms to regulate resource use (Lobe and Berkes, 2008).

It is difficult to exclude people from using fish resources, and as a common pool resource they are susceptible to “the tragedy of the commons” as described by Hardin (1968), if their use is not properly managed. The number of users has to be limited and the amount of resource any one user can appropriate has to be restricted, by developing arrangements that provide users with rights to the resources. Distribution of rights to marine living resources arrangements occur at a number levels (also discussed in Chapter 4) at the international level with regard to fishing on the high seas; at the regional levels through Regional Fisheries Management Organisations (RFMOs); bilateral agreements between two nations states; and within EEZs of nation states (Hoel and Kvalvik, 2006). At the national level the allocation and access to fisheries resources is a challenge for fisheries governance and management. There is the issue of allocation between fishery sectors, for example between recreational and commercial fishing sectors, and within individual sectors. Understanding the drivers for reallocating resources between sectors (which can be environmental, social or economic) is important when considering the management options and arrangements, and monitoring to assess the effectiveness of the reallocations (McPhee, 2008 pp. 155).

Defining and designing a system of rights that can be adapted to the particular ecosystem and human system characteristics of the fishery, involves balancing efficiency, equity and stewardship issues. There are the issues relating to the control of rights, in terms of whether the state maintains control of the fishery or assigns rights to individuals or groups. There are also management considerations relating to setting the goals and developing operational rules of the fishery, whether this is to be maintained by the state or via co-management arrangements. The creation of fishing rights is a question of efficiency, whereas the distribution of these rights and the potential economic gains are questions of equity. Determining an equitable distribution of resource rents between users and society (owners) is a distributional and political issue (Brady and Waldo, 2009). Property rights and resource rents are linked in terms of how economic rents can be generated over the long-term. Marine natural resources are in public ownership and are managed by government agencies on behalf of the whole community. Often where rents are generated they are appropriated by the resource users (Davis and Gartside, 2001).

Property rights are centred on a system of rights, rules and responsibilities that guide and control the human use of the natural resources. Environmental problems can arise from incomplete information combined with incomplete, inconsistent, or property rights that are not enforced or enforceable. Economic development and sustainable resource use depend on institutions that can protect and maintain the environment’s carrying capacity and resilience (Hanna et al., 1996 pp. 1-5). There are many types of property rights regimes, and they should be designed to fit the cultural, economic, geographic, and ecological context in which they are to function. Patterns of sustainable resource use may be overwhelmed by human population growth; increased demand for resources; and may be disrupted by technological, economic or environmental change. Property rights regimes link society to nature with the potential to co-ordinate human and natural systems, serving both ecological and human objectives. The challenge is that of designing property rights regimes which fulfil the goal of sustainability, equity, and efficiency (Hanna et al., 1996 pp. 1-10).

The nature of the property rights which govern access to natural resources plays a critical role in determining how efficiently they are used and who benefits. From an economic viewpoint, property rights and in particular the property rights regime is considered important in terms of efficient allocation and use of resources. The issue is not so much the type of property rights regime (private, state, or communal), but as to how the different regimes relate to each other, relate people to each other, and relate people to their natural environment, upon which social and economic development depend (Hanna et al., 1996, pp. 1-10). To achieve improvements of natural resource systems requires the development of institutions and property rights, with a focus on the users rather than the resource (Berkes and Folke, 2000 pp. 6-8).

A social concern regarding property rights allocation is the devolution of rights, especially individual rights, which might change the structure of fishing fleets and facilitate geographical concentration through agglomeration advantages, and may also result in the concentration of power and wealth to individuals, companies or regions. The allocation of rights to individuals or groups can represent a trade-off between transaction costs which can be reduced by moving towards smaller groups or individual rights, or exclusion that increase cost as a result. The issue is, which type of rights, individual or group would perform best given the particular conditions and circumstances of the fishery (Brady and Waldo, 2009).

Ostrom (2008) recognises that it is problematic to regulate common pool resources. In practice, according to Ostrom, there are no optimal rules that can be applied to all fisheries. For example common pool resources can be effectively managed through government ownership, community or private property arrangements. Individual transferable quota (ITQ) systems have been recommended as the optimal strategy. Those that have been successful have relied upon multiple institutional arrangements including effective monitoring systems, rather than just a simple ITQ system. What is needed are approaches which analyse the structure of common pool resources and how these change over time, and then adopt an approach that recognises multiple objectives, complexity and dynamics at a range of different spatial and temporal scales.

Individual Transferable Quotas

There is an extensive literature on the use of incentives where fishers' interests become more aligned to societal objectives (Grafton et al., 2007). An example is the use of individual harvesting rights. According to the Ward et al. (2002) while ITQs are a promising and popular tool, they are only one approach to allocating property rights, and have disadvantages in relation to ecosystem sustainability. There are perceived theoretical benefits in terms of the simplification of management procedures, and if owners are given long-term security of access to fishery resources, they are expected to operate and fish on a sustainable basis. There are, however, disadvantages: first, the assumption is that ITQs will provide an incentive to fishers to manage stocks over the long-term in order to maintain the ITQ value, but often ITQ systems have been unsuccessful in linking rights allocations to environmental responsibility, necessitating other forms of control to minimise environmental impacts. Second, ownership of ITQs may end up concentrated in the hands of a few owners, who may choose to use the economic business opportunities offered and not accept the responsibility for managing in a sustainable manner, and move on if the fishery fails (Ward et al., 2002 pp. 39-43).

There are other potential problem areas such as the initial ITQ allocations, which can be difficult and costly, and raise equity issues. Social impacts to small communities, which rely on fishing for employment, may also need to be considered. Fishery administration relies on good quality logbook data, and misreporting of catches and unreported discarding, or high grading of fish are often associated with ITQs and this is seen as an impediment to the success of the system. Management and compliance can be costly and difficult to monitor where there are numerous outlets for catch. Benefits can be negated if Total Allowable Catches (TACs) are over-estimated. TAC setting and uncertainties in determining stock assessment, which if not properly addressed could lead to unsustainable fish catches (Kaufmann et al., 1999). Multi-species fisheries can present particular difficulties for ITQ management. While some fishers have the ability to alter the species composition either by location choices, timing of trips, or alteration of fishing methods, the individual species mix will not exactly match the portfolio of catch rights. Some fishery managers have addressed this problem by allowing market transactions and management systems that allow for catch quota balancing (Sanchirico et al., 2006). In many fisheries traditional management tools and regulations have been retained, which may strengthen the use of ITQs (McGarvey, 2003).

The Organisation for Economic Co-operation and Development (OECD) undertook a study of the effectiveness of various fisheries management measures – the results suggest that ITQs are effective in controlling exploitation; mitigating the race to fish; generating resource rents and increased profit; and reducing the number of participants in a fishery. As expected single species fisheries performed better than multi-species fisheries, which are more difficult and costly to manage. The use of ITQs and bycatch in multi-species fisheries was raised as an issue. Methods to mitigate bycatch are determined by a variety of incentives through biological, social, economic, and regulatory constraints. Findings suggested that a fisherman will try to control bycatch as long as the benefits outweigh the costs, and management needs to recognise these constraints and create incentives. It was also suggested that there was no discernable increase in discarding at sea and underreporting under an ITQ system, as compared to limited effort management schemes (Sutinen, 1999).

Costello et al. (2008) tested the bio-economic theory that rights-based catch shares can provide individual incentives for sustainable harvesting of species, which are less prone to collapse. This was undertaken based on a global database, compiled from fisheries institutions and catch statistics in 11,135 fisheries from 1950 to 2003. A total of 121 fisheries using catch shares defined as variations on individual transferable quotas (ITQs) were identified. Results from this study indicated that ITQ fisheries perform far better than non-ITQ fisheries; ITQs slow and stops the decline in widespread fisheries collapse; and there is evidence of a strong link that ITQs align incentives leading to enhanced biological and economic performance. By 2003 the fraction of ITQ managed fisheries that were collapsed was half of the non-ITQ fisheries. Smith et al. (2009) urged caution in interpreting these results. The adoption of ITQs has not always prevented over-fishing; high grading is a common feature; and partial rights allocations can result in misreporting and failure to control catches. In the case of multi-species fisheries restrictions on quota species can lead to targeting and over-fishing of species not in the quota system; and placing all species within a fisheries management quota system would be expensive. Rights allocations tend to be an irreversible decision as changes may require government buyback. As Gibbs (2007) outlines allocating ITQ harvest rights (even in harvest only ITQs) can be considered to have an implicit spatial component in terms of access to fishing grounds. This can lead to future problems with regard to spatial allocations, rezoning for alternative marine uses, or the implementation of MPAs. These measures may exclude fishers from traditional fishing grounds without compensation, although governments can provide fishers compensation for loss of access to fishing grounds. Therefore, when designing ITQ regimes, allowance needs to be made for any future spatial demands (Gibbs, 2007).

5.4.4 Spatial and temporal management

The use of spatial and temporal measures in fisheries management, have a long history. Fisheries are managed within defined geographic areas; zoning may be applied within a fishery for specific purposes; and spatial and temporal closures can be used during critical species life stages. For example, seasonal closures for spawning events, or habitat protection reserves for critical habitat and dependent species. These are general examples; fishery management of individual fisheries may also use specific spatial and temporal measures. More recently MPAs have been considered as important in providing both non-fishery and fishery benefits for marine management, and for the implementation EBFM.

According to Douvre (2008), during the past ten years the evolution of marine spatial planning (MSP) and ocean zoning has been developed as a framework to facilitate an integrated and comprehensive spatial planning of all marine activities, within specified marine areas. MSP aims to provide a mechanism for a strategic and integrated planning approach to manage current and potential conflicting uses, the cumulative effects of human activities; marine protection; and balance the economic and social elements. The MSP process includes generating and adopting a spatial plan, implementation of the plan; assessing the effectiveness of the plan; and developing adaptive feedback processes. MSP has been used as a key element in the successful management of the Great Barrier Reef Marine Park.

Marine Protected Areas

MPAs can range from highly protected reserves to large multiple use areas. As a fisheries management tool some consider their establishment as a necessary condition for successful fisheries management (Degnbol et al., 2006). There has been significant interest in scaling up MPA practice by creating networks of MPAs with linkages between them, particularly since World Summit on Sustainable Development (WSSD) 2002, which called for nations to establish representative networks of MPAs by 2012 (Ecosystem Principles Advisory Panel, 1999; Cicin-Sain and Belfiore, 2005). Although MPAs offer a means to implement the precautionary approach and mitigate the effects on ecosystems of fishing, MPAs may not be effective on their own (Sissenwine and Mace, 2003). MPAs may be used in combination with other management measures, as part of an adaptive management approach and used as a tool for learning and experimentation that may assist in improving the long-term socio-economic welfare of coastal communities. A range of approaches, such as ecological assessments, ecological and economic modelling, and resource use analysis, is required to fully realise the potential of MPAs (Sumaila et al., 2000). According to Hilborn et al. (2004) while marine reserves are a promising tool for fisheries management and conservation of biodiversity, they are not a panacea for fisheries management problems. Initially there was a clear distinction between establishing MPAs for protection of biodiversity and those for fisheries management.

More recently international stakeholders have called for the large-scale implementation of MPAs (with up to 20-30% protection for oceans, and the elimination of consumptive uses within MPAs) on the basis that they will provide both conservation and fishery benefits, with little discussion on the potential costs. Day (2008) argues there are few monitoring programs that provide long-term monitoring, or an integrated assessment of the overall effectiveness of MPAs against the objectives, for which the area was declared. Surveys are important to over-come the problem of shifting baselines. Evaluation of MPAs needs to recognise the different purposes and objectives of MPAs, as approaches for managing a large multi-use MPA will be different from those of a small no-take MPAs.

Fishery benefits of MPAs are usually stated as being related to the maintenance of the natural age structure of stocks and protection of the spawning biomass. For less mobile and sessile species the aggregation of parental stock are believed to result in increased recruitment and migration to surrounding areas including those outside the MPA. The increase in size of individuals potentially results in greater egg production. Larvae produced in an MPA may settle within the boundaries of the MPA or be distributed outside. A large MPA is likely to be self-recruiting, emphasising the importance of positioning such that prevailing currents will maximise larval drift and settlement in depleted areas. In MPAs which are designed to increase fish production the expectation is that larvae will provide a recruitment subsidy outside the MPA (termed a spill-over effect). Besides protecting biodiversity MPAs may be used to protect fish stock, and provide a buffer against localised and large environmental fluctuations (King, 2007 pp. 306-309).

Despite these benefits a criticism is that protection and conservation is limited to relatively stationary species, with little protection for migratory species. Migratory species often lack information on migration and life states across boundaries, making it difficult to determine the biologically optimum size and number of protected areas needed to achieve management objectives for these species. MPAs may displace and concentrate fishing effort into other areas with the potential risk for over-exploitation. The socio-economic benefits of MPAs have been difficult to predict due to limited information regarding the biological responses and because the non-market values, such as biodiversity are difficult to assess. An assessment of MPAs world-wide found that less than 31% of those surveyed could be classified as achieving stated management objectives, mainly due to issues relating to size and design; economic and social aspects that were not considered; and lack of monitoring and enforcement (Degnbol et al., 2006).

As a management tool, MPAs require an effective governance regime that outlines the management rights, use and access rights; monitoring; and equitable distribution of the benefits and the costs (particularly those associated with fishing which may affect the livelihoods of dependent communities). MPAs are embedded within larger ecosystems and human systems. How existing or proposed MPAs are to fit to fit together, or be integrated into the broader governance and management arrangements needs to be considered (Charles and Wilson, 2009). Although MPAs may act as "banks" that protect fish stocks they cannot protect against threats outside the MPA. MPAs have traditionally been managed separately from the governance and management of the larger ocean and coastal area in which they are embedded. If managed in isolation MPAs are vulnerable to external impacts such as, over-fishing; pollution from coastal development; habitat destruction or modification; and other human activities. To date little work has been done in identifying the ecological, social and economic linkages between MPAs and the broader coastal and ocean management. The management of MPAs takes place within the context of a larger ocean governance system, but often with little or no integration with it. Likewise MPAs may be designed and implemented without recognition of the larger system within which it is located. To over-come these issues would require integrating MPA management into institutional arrangements for marine and coastal area management at local, regional and national levels (Cicin-Sain and Belfiore, 2005; Ehler, 2005).

5.4.5 Performance assessment, evaluation and reporting

As noted in Chapter 2, the World Summit on Sustainable Development (United Nations, 2002) encouraged the application by 2010 of the ecosystem approach. Therefore regional organisations, and nation states that have adopted the EBFM approach, will need to be able to demonstrate the incorporation of EBFM principles, actions and outcomes at regional and national governance and management arrangements. This will most likely require a review of what is required (international instruments and agreements); what is already in place (assessment and evaluation); and what is still needed (filing the gaps) at several levels. Institutions at all levels have a contribution to make in the review process. National level institutions may have the specialised data and expertise concerning various sectors, the capacity to harmonise sector activities; provide funding assistance; and has relevant links to bilateral, regional and international forums. At the local level there is often a more detailed understanding of the issues and problems and the constraints and limitations that will affect the choice of solutions; and access to local data and stakeholder networks. There are benefits of both top-down and bottom-up approaches. This could provide the opportunity for two-way feedback mechanisms where, for example, performance assessment of governance and management initiatives at the local level can feed back into the review processes at the national level. The national level can provide the context for stakeholders and institutions at all levels (Cicin-Sain and Knecht, 1998 pp. 121-125, 139-157).

Sustainability is the key principle of EBFM and the main purpose for its introduction. There is a need for assessments that can evaluate and report on the comprehensiveness and effectiveness of the whole fishery management system, in order to make a reliable assessment of sustainability. According to Day (2008), irrespective of any evaluation framework, the first and most fundamental requirement for measuring performance in managed systems are identifying the management objectives; defining the desired outcomes; identifying performance indicators; undertaking monitoring; assessing the results and reporting findings and recommendation; and adjusting management actions as necessary. Foden et al. (2008) reviewed a range of environmental assessments at local, national, and international scales. The review found that the amount and detail contained in assessments was highly variable. Of the 258 examples 7% were regarded as broad-based assessments; and 20% were classified as thematic assessments focusing on particular features such as fisheries, biodiversity or habitats. The purpose of the assessments also varied, as were the methodological approaches, and the target audience. In conducting a review process, assessors need to predetermine and define what the assessment is to comprise of, the methods to be used, and the standards against which measured parameters are to be judged. The ability of integrated ecosystems assessments to predict future scenarios can be dependent on the approach adopted which can have implications for management practices. Currently, in many of the assessment reviewed, some of the important factors are not being met, limiting the utility of these assessment findings.

As outlined by Leadbitter and Ward (2007) an integrated fishery assessment is defined as a cohesive and comprehensive set of principles, criteria and assessment approaches to determine the effectiveness of a system used to manage a fishery. Assessment systems require a high degree of rigour and robustness for credibility in terms of the purpose they were designed for, and the ability to demonstrate the effectiveness of the system being assessed (Leadbitter and Ward, 2007 pp. 459-460). Although the primary purpose is to assess and report on the effectiveness and performance of the management system, the overall result of the assessment of a particular fishery can vary according to which assessment approach is used. For example, the purpose of the Unilever traffic light system is an internal fishery assessment system designed to evaluate fishery products for purchase by the Unilever group of companies with green considered the most sustainable. The Marine Stewardship Council (MSC) accreditation and eco-labelling approach is based on a set of principles, criteria and agreed standards, with accreditation by independent certifiers. This approach is voluntary and industry led which provides fishers with an incentive for sustainability based on market share and provides consumers with the ability to choose sustainably harvested fish products. RapFish is a sophisticated quantitative fishery assessment approach providing technical data and analysis, which may compare one fishery with another, or a real fishery against a theoretically ideal fishery, in order to establish a relative performance level for the fishery being assessed (Leadbitter and Ward, 2007 pp. 463-465).

Leadbitter and Ward (2007) also note that a set of evaluation criteria is necessary in making a robust and defendable assessment of the fishery. This requires comprehensiveness; transparency and accountability; and declaration of the nature, use and quality of the data. Comprehensiveness relates to the fishery management system and the assessment system and includes five key aspects: stock condition and performance; environmental impacts of the fishery; social and economic impacts of the fishery; food security at local, national and regional levels; and, scope of the management system. The imperative for transparency extends to any assumptions, implicit and explicit in the models, and data and information used as a basis for judgements in any specific fishery assessment. The assessment system needs to be explicit about the sources of data and information and how they are treated during the assessment process, based on the following criteria, the data, models and assumptions are scientifically robust; sources of data and information are explicit, and are independently verifiable; treatment of data is transparent; and there is internal consistency and repeatability of any data analysis process (Leadbitter and Ward, 2007 pp. 461-463).

5.4.6 Knowledge, research and data management

Knowledge and research is important for stakeholder and society's understanding of the biophysical and human system dynamics, when evaluating proposed development activities, or considering proposed management solutions to problems. There is need for co-ordinated research and data collection, as well as better use of existing data. Current ecosystem knowledge is provisional, incomplete and subject to change, and further research will be necessary where information gaps are identified. Appropriate data and information is required for management performance assessment and evaluation, as well as to establish baseline data to monitor changes in the state and dynamics of particular ecosystems (Grumbine, 1994; Christensen et al., 1996; Ecosystem Principles Advisory Panel, 1999; Ward et al., 2002).

Knowledge and date management

As discussed in Chapter 2, a key lesson highlighted in the literature is that EBFM will require a multi-disciplinary and trans-disciplinary approach. Fischer et al. (2007) suggest that it requires the integration across academic disciplines, and the integration of academic insights into decision-making and societal action. Integration across academic disciplines has drawn on the biophysical and social sciences, particularly ecology and economics. Integration of research with regard to decision-making in societal action increasingly occurs through participatory methods, such as scenario planning and policy management tools. Costanza (2003) argues that science as an activity requires a balance between analysis (the ability to break down a problem into its constituent parts and understand how they function); and synthesis (the ability to put the pieces back together in a creative way in order to solve problems). Practical problem solving requires the integration of three elements the creation of a shared vision of both how the world works and how we would like the world to be; a systematic analysis appropriate to and consistent with the vision; and implementation appropriate to the vision.

For any given situation fisheries management needs to determine the knowledge required, the degree of precision needed, and whether additional research would improve the outcomes (Charles, 2001 p. 122). Indicators play two roles in fisheries management. One is reporting on the effectiveness of past management actions to achieve biological, economic and social objectives for the fishery (the audit function); and the other is guiding decisions about the provisions of the management plan, both rely on a range of data and information (Symes, 2007). Although there is available data, often the communication and sharing of results have not been well co-ordinated, or made available in a form useful to management. There has also been reluctance by science to integrate other relevant sources of information, such as local and indigenous knowledge with scientific and technical information (Hartje et al., 2003 pp. 13-14).

Decision-making according to Cicin-Sain and Knecht (1998); and Berghofer et al. (2008) should be based on the use of the best information and scientific research that is available. This is important as decision outcomes need to be defensible as they may affect stakeholders differently. Interested parties (current and future) need to be able to determine the basis on which decisions (knowledge and data) have been made, including uncertainties where data is missing or not comprehensive. Each nation will have specific data and information needs. This will be dependent upon resource use issues; the activities to managed and potential impacts; the structure of the governance and management systems; and the status of existing data and information. Therefore the types of data, its analysis and application, and presentation, are important considerations (Cicin-Sain and Knecht, 1998 pp. 171-182; Berghofer et al., 2008).

As discussed by Failing et al. (2007) while there may be little utility in strictly defining between the different types of knowledge, the principles of decision analyses suggest that it is useful to distinguish between whether the knowledge claim is fact based or descriptive, or value based or prescriptive. How these types of judgements are treated in decision-making and who has the legitimacy to make them should differ, but in practice a clear distinction is often not made. Both facts and values are needed to inform policy-making processes, and in structured decision-making processes. Choices among alternatives will involve addressing trade-offs between competing objectives; and methods for making choices should allow stakeholders to state preferences (value based) based on reliable fact based information.

There will be similar information needs and data overlaps between different institutions and decision makers, but they will require different details and aggregation at the different levels from national to local levels, and will be dependent upon the issues, purpose and use (FAO, 2003). Many of the existing fishery tools and those developed for EBFM such as MSE, risk assessments, models; accreditation schemes, FMPS, and fisheries assessments require similar information regarding the fishery, such as background information and analysis regarding the environmental, economic and social aspects of the fishery; descriptions of the fishing activities, resources and the ecosystems; and other issues internal and external to the fishery.

Research

EBFM requires the incorporation of broader environmental, economic and social considerations and this will also broaden information needs, and may require further research to fill the knowledge gaps. Charles (2001 p. 121) discusses information dynamics in terms of the processes of collection and incorporating new information as it becomes available, so that it can inform decision-making in a timely manner. The three key components are:

- monitoring: the collection, on a regular basis, of useful data to assess fishery performance;
- research: the study of fundamental questions, adding to our base of knowledge; and
- decision support: the provision of science based assessments to aid decision-making.

The four key options for structuring research are by:

- discipline: a multi-disciplinary approach;

- species: individual or groups of species;
- geographical or ecosystem: on the basis of geographical units or ecosystems to address topics of concern in a particular area or ecosystem; or
- function: links research activity with the principal areas of a fishery management system such as habitat protection, stock assessment, resource management, ocean science, or fishery development (Charles, 2001 pp. 121-137).

There is a wide range of participants in fisheries research, data collection, and analysis for fisheries (including governments, international agencies, universities; the fishing sector, private sector and non-governmental organisations). The data and research outcomes need to be communicated, disseminated and shared (Charles, 2001). It is also possible to learn from other experiences elsewhere, however it is important to assess under what circumstances other initiatives may be adopted. There may be significant differences in the structures and processes of systems, operating at different spatial and temporal scales, which limit the adoption in other fisheries (Cicin-Sain and Knecht, 1998 pp. 121-125).

5.5 A Management and decision subsystems model

As discussed above Management Strategy Evaluation (MSE) in the broad sense involves assessing the consequences of a range of management strategies or options and presenting the results in a way which lays bare the trade-offs in performance across a range of management objectives. MSE is a simulation technique based on modelling (using qualitative or quantitative models) each part of the adaptive management cycle in terms of defining the management objectives, simulating the dynamics of the system and management decision processes and assessing the outcomes. It should be noted however, that it takes multiple iterations to achieve. More recently ecosystem-based management and multiple use management questions have been addressed using the MSE approach (Butterworth and Punt, 1999; Sainsbury et al., 2000). As the EBFM is a risk-based approach to managing fisheries, a number of risk assessment approaches has been developed which aid decision-making.

On the basis of the preceding discussions, the management and decision-making subsystems of the model, has been further developed, as per Figure 5.5 below. This model highlights the important aspects relating to strategic management and some of the tools available to aid decision-making; and operational management processes and measures and some of the tools available in the fisheries toolbox. Assessment and evaluation are important to fisheries management, and particularly for enabling the application of adaptive management which facilitates learning. Qualitative and quantitative knowledge, together with a multi-disciplinary and trans-disciplinary approach is fundamental to informed decision-making under EBFM principles.

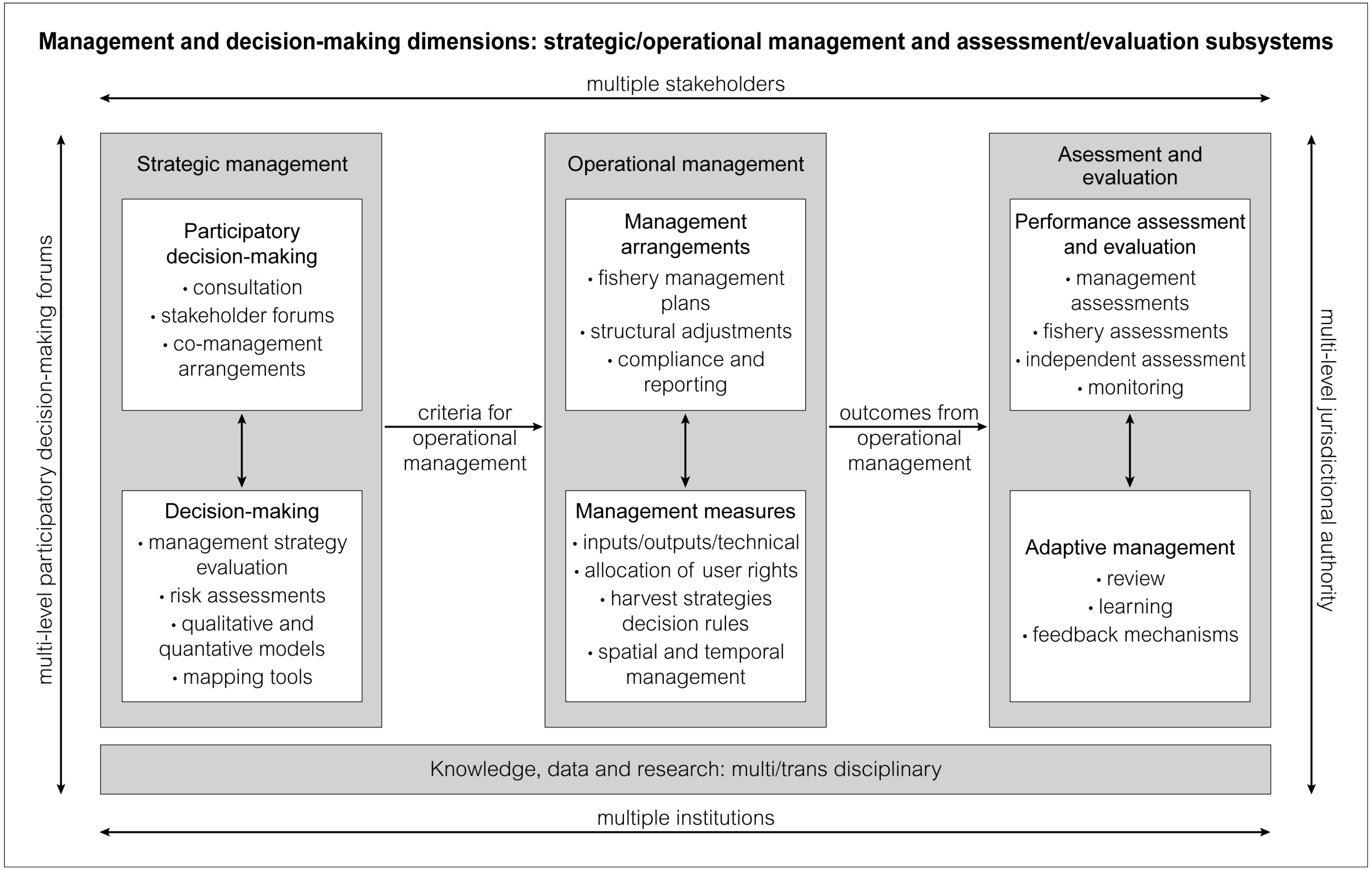


Figure 5.5: Management and decision-making dimensions subsystems model.

5.6 Summary

The focus of this Chapter was on elements considered necessary for implementation of EBFM at the national level. While there is a need for further development, there are already effective strategic and operational management procedures and processes in place that support the EBFM approach. The important strategic and operational management aspects and tools considered necessary for the successful implementation of EBFM as discussed include management arrangements and decision-making tools; fishery management plans; management processes and measures (including harvest strategies and allocation of user rights such, as ITQs); spatial management; compliance and enforcement; and performance assessment. EBFM will require a wider range of information to be incorporated into any decision-making process. A systems approach is considered necessary to facilitate implementation as it provides a framework for implementation, from which criteria for evaluation and assessment can then be developed. There are many aspects to be considered when implementing EBFM and only a few components have been discussed here, but in practice implementation is context dependent and multi-faceted. Without a comprehensive and consistent approach to implementation, it is going to be difficult for any nation to know whether EBFM has been fully implemented (a phrase that is often used) and the ability to assess whether initiatives have been successful or not (learning by doing) so that an adaptive management approach (considered a key element) can be put into practice.

Rice (2008) argues an ecosystem approach does not necessarily require fully integrated management of all ecosystem and human system activities, but it does require placing fisheries management within an ecosystem context. However, the EBFM concept requires sustainability to be achieved across all dimensions, ecosystems, economic, social and institutional. Fisheries issues existed under previous management regimes (where the context of fisheries issues were narrowly defined), whereas EBFM requires them to be explicitly considered (broadly defined). The integration of the ecosystems and human systems dimensions are recognised as important in framing the broader aspects and context of fisheries systems. This does not necessarily address the conflicts and issues but can provide insights as to how different perspectives could be combined that result in a more comprehensive approach. However, there are few examples of a fully integrated approach, and the social aspects often tend to be excluded (White et al., 2009). Arnason (2009) suggests that a fisheries management system includes well defined objectives as a necessary prerequisite for fisheries management; choices regarding which management system to adopt and what management measures to select; and specifies the regulatory framework. The fisheries management regime also requires a balance between efficacy and its cost of design, implementation and operation.

In this Chapter (and preceeding Chapters) an integrated systems model for fisheries under EBFM principles has been developed. Chapter 2, outlined sustainable development and EBFM concepts and approaches; and the key aspects and elements that underpin them were identified, and introduced the integrated systems model for fisheries. Chapter 3 examined the environmental, economic and social dimensions (components, characteristics, and drivers), and incorporated them within a biosocioeconomic subsystems model. In Chapter 4 the governance and institutional dimensions were investigated and the governance and management subsystem model was further developed. Chapter 5 identified the management and decision-making dimensions; incorporated the strategic and operational management arrangements and measures; and the assessment and evaluation subsystems, within the systems model. Together these form the integrated systems model under EBFM principles as presented in Figure 5.6 below.

The model highlights the interconnected nature of ecosystems and human systems at a range of spatial and temporal scales. Human activities may impact ecosystems, and in turn ecosystems may respond with changes and surprises, that affectct human systems. Likewise outcomes from governance and management responses and measures may effect the biosocioeconomic dimensions in unpredictable and unforeseen ways. Under these conditions complexity and uncertainty is a feature of the system. The challenge for governance and management is the difficulty of predicting outcomes and consequences of policy and management actions, and of minimising the risks to ecosystems and human systems.

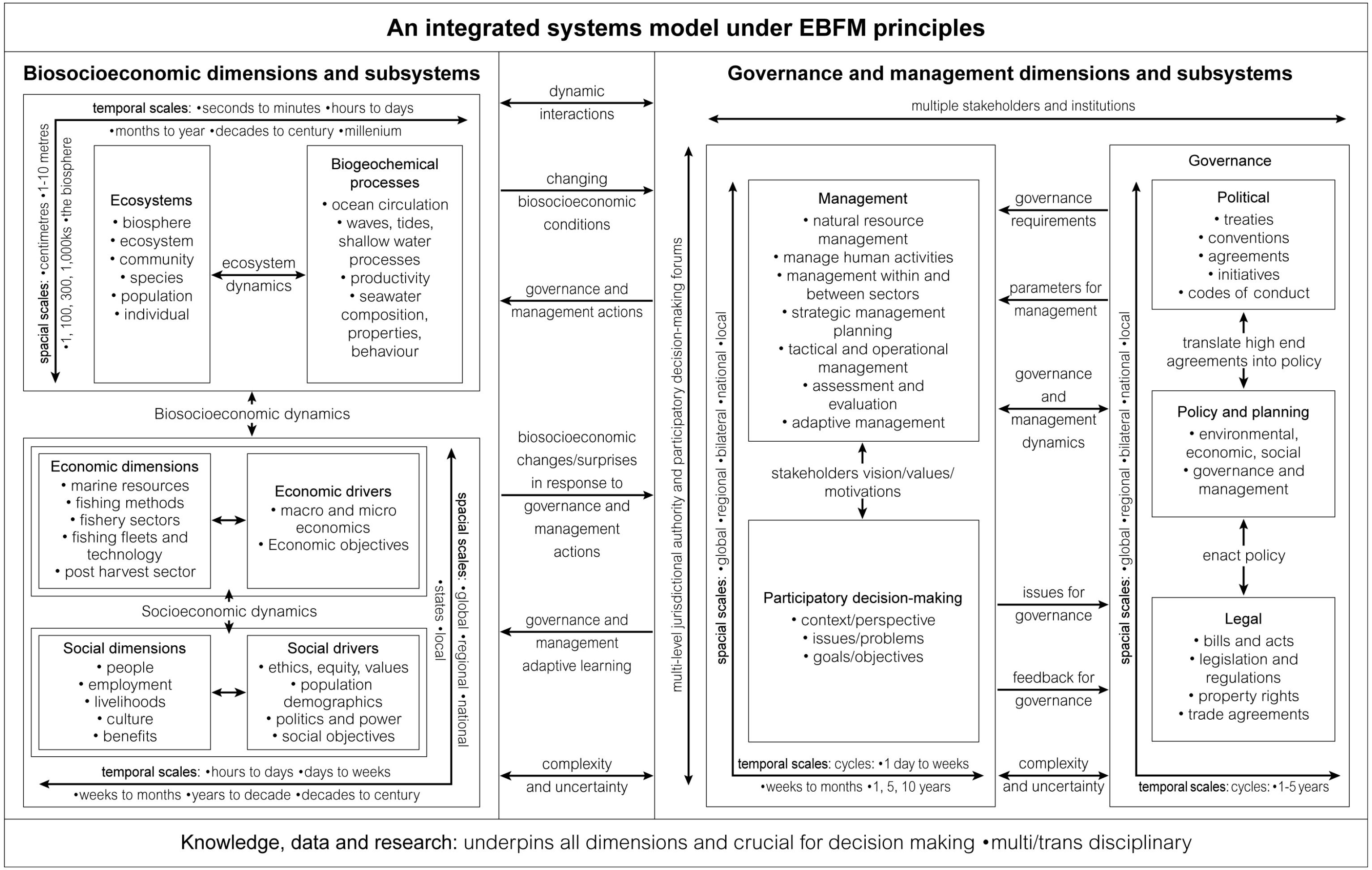


Figure 5.6: An integrated systems model under EBFM principles.

This systems approach and integrated model will be applied to illustrate its validity and application in Australia in Part Two of the thesis. Australia’s response to sustainable development and the adoption and implementation of EBFM as a policy framework for managing ocean and fisheries will be examined, and governance and management arrangements assessed. Australia’s biosocioeconomic fishery dimensions will be investigated. The governance and management of Australia’s Commonwealth and state and territory fisheries under Ecologically Sustainable Development (ESD) and EBFM principles will be investigated. The implementation of EBFM at the fishery level will be identified through two case studies. One a Commonwealth fishery managed by Australian Fisheries Management Authority, in this case the Southern and Eastern Scalefish and Shark Fishery (SESSF); and the other a Western Australian fishery managed by the State Department of Fisheries, the West Coast Rock Lobster Fishery (WCRLF).

CHAPTER 6: OCEANS AND FISHERIES IN AUSTRALIA: THE POLICY FRAMEWORK

6.1 Introduction

In November 1994 Australia became responsible, under the provisions of the United Nations Convention on the Law of the Sea (LOSC), for the third largest ocean territory in the world. Under the LOSC Australia is responsible for the biological diversity and sustainable development of the oceans and fisheries resources within its Exclusive Economic Zone (EEZ). The Australian marine environment has unique characteristics and ecosystems and biodiversity values of international and national significance, for example, the Great Barrier Reef is listed as a world heritage area. Australia's Exclusive Economic Zone has a wide range of habitat types, but is largely unexplored, and due to its long geographical isolation many species are endemic. The EEZ extends from the Antarctic to the tropics, and contains a large portion of the southern hemisphere's marine biological diversity (Zann, 1995).

Marine ecosystem goods and services provide Australia with a wide range of economic and social benefits and opportunities. These include marine industries such as fisheries, tourism, petroleum, shipping, ship building, and port based activities, which make a significant contribution to the Australian economy and society. For the period 2002/03 the largest marine industry was tourism, which contributed 42.3% of value added, and 75.3% of employment; and is a particularly important sector for New South Wales (NSW), Queensland (QLD), South Australia (SA), Northern Territory (NT) and Tasmania (TAS). The offshore oil and gas industry contributed 41.8% value added and accounts for the majority of marine industry exports, but it is a relatively small employer and is the dominant industry in Victoria (VIC), Western Australia (WA) and NT. Fisheries and the seafood sector was the third largest marine industry and it is the most labour intensive of all marine industries, and is an important activity in all states (The Allen Consulting Group, 2004 pp. iv; 29-31; Australian Institute of Marine Science, November 2008).

The systems approach and integrated model will be used to examine Australia's position within international and regional forums, and at the national level with regard to oceans and fisheries governance and management. Australia engages in many international and regional forums regarding oceans and fisheries governance and management. Australia is party to many international instruments and regional agreements, and is responsible for incorporating the requirements of these into domestic governance and management arrangements. Australia also has a national responsibility for managing oceans and fisheries resources within its EEZ. Australia has developed a policy framework that in turn is critical to give effect to the international instrument and regional agreements; the development and adoption of Ecologically Sustainable Development (ESD), and (EBFM); and in identifying and responding to the current and emerging national oceans and fisheries issues. This Chapter briefly outlines Australia's international, regional and bilateral roles and responsibilities; the development of ESD and EBFM; the key issues arising in oceans and fisheries, and presents the governance and management responses to those challenges. Australia's multi-level and multi-institutional governance and management arrangements will be discussed.

6.2 Australia's international, regional and bilateral participation and role

Australia participates in a number of international forums, for example, the FAO; the Asia Pacific Economic co-operation; and the Pacific Ocean Fora. Australia is also party to a number of the international conventions and instruments, that were outlined in Chapter 2. To identify all the key documents and to assess how the requirements of the international instruments and agreements have been incorporated into governance and management arrangements in Australia, is beyond the scope of the thesis. What can be demonstrated is the incorporation of key outcomes from the 1987 World Commission on Environment and Development (World Commission on Environment and Development (WECD), 1987), the 1992 United Nations Conference on Environment and Development (United Nations Conference on the Environment and Development, 1992a and United Nations Conference on the Environment and Development, 1992b), and the 2002 United Nations World Summit on Sustainable Development (WSSD) (United Nations, 2002) into a national policy framework.

6.2.1 Commitments under WSSD 2002

Commitments under the WSSD 2002 Johannesburg Plan of Implementation (United Nations, 2002) include:

- The establishment, by 2012, of a representative network of marine protected areas, and integrated marine and coastal area planning and management (United Nations, 2002). Australia's Oceans Policy and the *Environmental Protection and Biodiversity* (*EPBC) Act 1999,* both provide provisions for these. Australia's National Representative System of Marine Protected Areas (NRSMPA) was established in order to develop and provide a national network of comprehensive, adequate and representative MPAs. These are declared by the Commonwealth and state governments under their respective legislation, with implementation and management undertaken by a range of government agencies. National policies have also been developed to facilitate an integrated approach to marine and coastal area planning and management of the land and marine interface as outlined in Table 6.5.3 below.

- To encourage by 2010 the application of an ecosystem approach (United Nations, 2002). In Australia EBM has been adopted under Oceans Policy and fisheries jurisdictions, which provides a national integrated and ecosystems based oceans and planning and management framework for managing marine sectors including fisheries, based on large marine areas. Under the EPBC Act where actions are likely to impact on matters of national environmental significance, approval is required from the Minister for the Environmental (Department of the Environment, Water, Heritage and the Arts, 2009). It is mandatory for all export fisheries to undertake strategic assessments to determine that management arrangements will ensure the fishery is managed in an ecologically sustainable manner. In 2006 all jurisdictions adopted EBFM as a policy goal for fisheries.

- To maintain, or restore, depleted fish stocks to levels that can produce the maximum sustainable yield, and for depleted stocks where possible by 2015 (United Nations, 2002). For example the Bureau of Rural Sciences (BRS) in its annual Fishery Status report identified a number of species in Australia's Commonwealth managed fisheries that were over-fished and where fish stocks required rebuilding. In 2007 the Commonwealth Harvest Strategy Policy (HSP) was introduced for all Australian Commonwealth managed fisheries, and to be implemented by 1 January 2008 (Smith et al., 2007).

- The request for implementation of the FAO International Plans of Action (IPOAs), regarding fishing capacity seabords, sharks and illegal, unreported and unregulated fishing (IUU) by the agreed dates. In response Australia has developed a Threat Abatement Plan (TAP) to mitigate the take of seabirds in longline fisheries, June 2003 and revised in 2006; a National Plan of Action for the conservation and management of sharks May 2004; and National Plan of Action to Prevent, Deter and Eliminate IUU Fishing 2005. As outlined in Table 6.5.3 below.

In preparation for WSSD 2002 some major problems and constraints were identified – including the fragmentation and the lack of co-ordination and harmonisation of international agreements (Bernal et al., 2001). Australia also has problems of incorporating international instruments into domestic legal arrangements, and effective national legislation as outlined in a number of selected reviews summarised below. Tsamenyi et al. (2003) examined Australia's implementation of three international instruments dealing with marine conservation, the *Convention of International Trade in Endangered Species of Wild Fauna and Flora* (CITES) 1973, *The Convention on Wetlands of International Importance especially as Water Fowl Habitat* (Ramsar) 1971, and the *Convention on Biological Diversity 1992*.

The legislative and policy response to the implementation of these instruments in Australia by the Commonwealth and states and territories reveals weaknesses in the legislative and policy framework. The Commonwealth has comprehensive legislation and policy to implement and further develop most of the objectives of the Conventions. In some instances, however the states and territories have often relied on pre-existing legislation, rather than implementing specific legislation specifically aimed at achieving the instrument's objectives. Under the Offshore Constitutional Settlement the division of marine jurisdiction between Commonwealth and states and territories has resulted in some areas being covered by a strong legislative framework, but not others (Tsamenyi et al., 2003 p. 2). This may cause problems where the implementation of international instruments is more limited in State waters than in Commonwealth waters. There are other cross-jurisdictional implications, such as managing straddling stocks where mobile marine species cross jurisdictional boundaries. These jurisdictional realities may reduce the ability of Australia to fully implement its obligations under these instruments.

A detailed and comprehensive review of a selection of existing Commonwealth and state marine related environmental laws was undertaken by the Australian Conservation Foundation (ACF). The results of the review considered that the laws, which apply to the conservation, fisheries, petroleum, shipping and tourism sectors, were inadequate to provide integrated and pro-active marine management for ESD or ecosystem-based management (Australian Conservation Foundation, 2005 pp. 6-8). The review however, identified that legislation related to marine ecosystems was starting to incorporate sustainability principles into decision-making processes. The majority of Acts reviewed contain sustainability principles in the objects clauses of the legislation, particularly for the conservation and fisheries sectors. On the whole, the majority of legislation reviewed did not expressly require principles of ESD to be considered in decisions made under the legislative regime. The most advanced form of mandating sustainability in decision-making was found in the key conservation legislation such as the Commonwealth EPBC Act, which contains an extensive definition of ESD incorporating a requirement to consider short and long-term economic, environmental, social and equity considerations. ESD is one of the mandatory factors to be considered by the Minister in granting approval for an action that may impact on matters of national environmental significance. Many state conservation acts appeared to be outdated and did not expressly, or imply incorporation of ESD principles into the objectives, or the decision-making of the Act. Commonwealth Fisheries Management legislation expressly incorporates ESD into the objects of the Act, and the Minister is required to pursue the objects of the Act in administering it. The majority of state legislation that expressly incorporated ESD into the objects and required consideration of objectives in decisions, tended to be those with more recent legislation, for example from 1994 onwards (Australian Conservation Foundation, 2005 pp. 2-3).

The ACF review of legislation revealed numerous barriers to implementation of ecosystem-based management (EBM) due to the predominantely sectoral and species focused existing legislation. The review noted that the legislation which best attempted to address ecosystems management was the EPBC Act. The majority of the operative provisions under the Act generally focus on individual species. The *Great Barrier Reef Marine Park Act 1975* was cited as a good example of an attempt to incorporate an ecosystems approach to management. Some state legislations reviewed incorporated ecosystem considerations in the objectives of the Act, but others did not provide for an ecosystems-based approach. The Commonwealth's *Fisheries Management Act 1991* incorporates EFBM through the use of management plans, which aim to achieve ecosystem integrity, but the main focus of the Act is on target species rather than on ecosystems. The majority of state fisheries legislation attempts to incorporate concepts of ecosystem integrity and habitat protection into management frameworks for specific fisheries. The Commonwealth and the states define fisheries by fishery jurisdiction, target species and fishery methods, rather than by habitat and ecosystem boundaries (Australian Conservation Foundation, 2005 pp. 4-6).

6.2.2 Positioning Australian fisheries: international, regional and bilateral arrangements

Globalisation and the growing inter-dependence between fisheries and markets occurs through trade in fish and fish products; foreign direct investment in harvesting and processing; and through fisheries services. Several events have supported the interdependence of markets and resources. These were the extension of Exclusive Economic Zone (EEZs) to 200 miles from 1977, which led to important redistribution of fishing possibilities; the change in demand for fishery products; over-exploitation of resources in the developed world; the role of developing countries in supplying global demand; and the role of technology (Schmidt, 2004 pp. 93-108). Globalisation can give rise to a complex set of relationships including harvesting and production, processing, distribution and trade. The challenge is to understand the impacts of globalisation at each level of activity, the linkages up and down the chain from producers to consumers and vice versa; as well as the policy, institutional practices and governance needs at each stage, in order to maximise benefits and minimise risks (Ridgeway, 2007 pp.11-20).

Over the last decade fisheries trade has increased more rapidly than fisheries production. The market for fish products is strong but growth potential is limited for wild capture fisheries, and aquaculture now represents a large share of international trade. The biggest challenge is managing wild caught fisheries and aquaculture on a sustainable basis (Valdimarsson, 2009 pp. 17-18; Anderson and Valderrama, 2009 pp. 27-28). Seafood prices are set on world markets and Australia is a small producer of fisheries products. Over the last decade the real value of Australian fisheries production has declined at an annual rate of 4.7%, and aquaculture at 1.1% over the same period. The factors affecting the export value of Australian seafood products can be attributed to a fall in the volume of edible fisheries products exports (fallen by 26% since 2000/2001); the prices of fisheries products fell on world markets; and the appreciating Australian dollar against the currencies of major trading partners reduced the prices received by Australian exporters (Hohnen et al., 2008 pp. 21-23).

Williams (2007) notes that Australia and the Southeast Asian countries are "enmeshed" through connections regarding fish and fishing which may provide opportunities as well as generating tensions. Indonesia is Australia's nearest neighbour; Thailand and Vietnam are key fish suppliers to Australia; and the Philippines and Papua New Guinea figure in regional tuna and fishing trade. Australia's fisheries are modest in size when compared to those of Southeast Asia, although they are high in value. Currently Southeast Asia countries supply nearly 50% of Australia's fish imports in order to meet Australia's domestic market demand for fish products. Projections of Australia's fish requirements and likely domestic production to 2020 and 2050 indicate that Australia will become more reliant on imports. The major tensions between Australia and the Southeast Asian countries relate to illegal cross border fishing, and the challenges of managing bilaterally shared fish stocks; the challenges of multi-lateral management of regional tuna fisheries, and the interdependence of the fish trade. In general the tensions arise because over-fishing is now a problem in each country, and is compounded in the Southeast Asian countries where there is a lack of effective controls on the amount of fishing and drivers for food, profit, livelihood and foreign exchange (Williams, 2007 pp. 1-10). Williams (2007) argues that a proactive and comprehensive engagement regarding fisheries is required to deal with the issues of depleted regional fish stocks, greater competition for these stocks and rising market demand for fish. Australia's fisheries are different to those of the overall region; as are its economic, social and demographic structures; and approach to managing fisheries and the marine environment when compared to its Southeast Asian neighbours (Williams, 2007 pp. 89-94).

Nation states are sovereign, but are required to collaborate and co-operate with other nations within regional and global forums. Australia participates in a number of Regional Fisheries Management Organisations (RFMOs) under the Regional Seas Programme. For example, Australia is party to the Commission for the Indian Ocean Tuna Commission (IOTC); the Commission for Conservation of Southern Bluefin Tuna (CCSBT); and the Western and Central Pacific Fishery Commission (WCPFC). Participation in these organisations is important given the valuable tuna fisheries in Australia, such as the Commonwealth managed Eastern Tuna and Billfish Fishery. The Australian Antarctic Division is the lead agency regarding Australia’s involvement in Conservation of Antarctic Marine Living Resources (CCAMLR). Australia has a commercial interest in the Patagonian toothfish fishery at Heard and the McDonald Islands. Australia’s major priority within CCAMLR is to seek stronger measures to effectively combat IUU fishing (Department of Agriculture, Fisheries and Forestry, 5 November 2008).

The primary forum for fisheries and aquaculture co-operation between Australia and Indonesia is the Australia-Indonesia Working Group on Marine Affairs and Fisheries. The Working Group aims to co-ordinate and facilitate future co-operation in the areas of fisheries and aquaculture management; research and development; marine environmental conservation; and marine biotechnology research and development. A current issue for the Australia-Indonesia relationship is Illegal, Unregulated and Unreported (IUU) fishing (Department of Agriculture, Fisheries and Forestry, 6 September 2006a). Australia and New Zealand have a strong co-operative relationship in managing the fisheries resources in the high seas areas adjacent to the respective fishing zones. Recent consultations have been related to bilateral and multi-lateral issues, such as shared management arrangements, participation in regional fisheries management organisations, and strategies for controlling IUU fishing (Department of Agriculture, Fisheries and Forestry, 6 September 2006b). The Torres Strait Treaty was entered into by Australia and Papua New Guinea and it is concerned with sovereignty and maritime boundaries in the area between the two countries, the protection of the marine environment and the optimum utilisation of commercial resources in the region. Under the *Torres Strait Fisheries Act 1984*, the prawn, tropical rock lobster, pearl shell, Spanish mackerel (all commercial harvests), and dugong and turtle fisheries are jointly managed by Papua New Guinea and Australia (Department of Agriculture, Fisheries and Forestry, 1 October 2008).

6.3 Adoption and development of ESD in Australian fisheries

Despite the prominence of ESD as a fishery management objective in all Australian jurisdictions, by 1998 it was recognised that there was a gap between intention and practice; differences in consistency in application, and there was a lack of sharing of experience across jurisdictions. It was accepted that there was a need to progress, and be able to report on all components of ESD. State and Commonwealth fisheries management agencies are accountable for meeting ESD requirements under their respective legislation and demonstrating these objectives are being met. There was a need, therefore, for fishery management agencies to be able to measure and report on progress against the objectives of ESD through the use of sustainability criteria, indicators and associated measures of performance. The need for a comprehensive and practical reporting system was also driven by the development and implementation of Oceans Policy 1998 strategies; the imminent introduction of the EPBC Act in meeting benchmarks for the environmental assessment of fisheries; and a number of policy changes, such as the proposal by Environment Australia to amend Schedule 4 of the *Wildlife Protection Act 1982*, regarding the exemption of fisheries for export and imports. The fishing industry was also interested in gaining market access under accreditation schemes such as the Marine Stewardship Council, and this approach would be beneficial in demonstrating sustainability (Smith and Hodge, June 2001 p. 1).

In response to these pressures and interests, the Standing Committee on Fisheries and Aquaculture (SCFA) a forum of Commonwealth and state fisheries officials indentified the need to actively progress the development of a nationally agreed criteria and indicators that would enable fisheries managers to report against all the principles of ESD. A SCFA Working Group was established to steer the development of ESD criteria and indicators with the support of the SCFA Research Committee. To ensure that the results would obtain national recognition and support, an ESD Reference Group was established to ensure consultation and participation of stakeholders. These included representatives from Environment Australia; commercial fisheries; aquaculture; recreational fisheries, Indigenous groups; Fisheries Research and Development Corporation (FRDC); non-government organisations (NGOs); environmental groups; and other relevant experts. The Reference Group was to work in partnership with the SCFA Working Group to assist in the co-ordination and exchange of information (Smith and Hodge, June 2001 p. 1).

As a result FRDC supported a number of projects as part of the development of the SCFA approach. This included the *Framework for assessing performance against the ESD objectives of Commonwealth fisheries management* (Chesson and Clayton, 1998) to determine how well ESD requirements were being met; and the development of the Bureau of Rural Sciences (BRS) framework based on component trees, which included the ecological, economic, social and governance. An outcome from the *Current use and recommendations for future development of sustainability indicators to measure performance of Australian fisheries against ESD objectives* (Sainsbury et al., 1998) was a recommendation for the development of a nationally co-ordinated research and development program on sustainability indicators. The main aim of the program was to develop options for sustainability indicators and guidelines for their use, that were acceptable to all jurisdictions. The program was to be linked to the Standing Committee on Fisheries and Aquaculture (SCFA) processes and included all jurisdictions. The response was the formation of the FRDC Ecologically Sustainable Development Reporting and Assessment (ESDRA) Sub-program, which was part of a national initiative to implement ESD within all jurisdictions and across Australia's commercial fisheries and aquaculture sectors. It aimed to assist fishery managers, the industry, environmental groups and the wider community in understanding ESD and issues relating to fisheries; the initiatives that were underway; to develop methods to assess ESD performance in fisheries; the structures which have been put in place to assist these initiatives; and the progress made in moving towards ESD based fisheries management. The objectives of the ESDRA Subprogram were to:

- act as the co-ordinating hub for the development of information and tools for ESD reporting and assessment;

- facilitate practical implementation of ESD initiatives by providing a leadership role;
- co-ordinate and facilitate the development and evaluation of relevant applications on the reporting and assessment of ESD;
- facilitate the participation of the ESDRA Reference Group;
- assist project integration and value-adding through regular project workshops; and
- co-ordinate the formulation and delivery of the ESDRA communications strategy.

(Fisheries Research and Development Corporation ESD Subprogram, 2010)

The work undertaken by ESDRA subprogram since the 1998 review is discussed in Chapter 7.

6.4 National governance and management

Australia's adoption of ESD and EBFM as the basis for governance and management of oceans and fisheries are articulated in three mutually supporting government policies;

- The 1992 National Strategy for Ecologically Sustainable Development (NSESD), a whole of government approach to natural resource management requiring consideration of the environmental, economic and social dimensions and the interests of current and future generations.
- The 1998 Ocean Policy (including subsequent changes in 2005) provides for sectoral management through bioregional plans, based on large marine ecosystems, and the identification of MPAs.
- The EPBC Act aims to provide a framework for environmental protection and conservation of biodiversity and incorporates the EBFM approach to fisheries management, and in 2006 EBFM was adopted by all fisheries jurisdictions as a policy goal.

These instruments provide a national framework for the development of policy initiatives in response to environmental, economic and social issues. Aspects of these instruments and their application to fisheries are presented below, together with a summary and recommendations from selected independent reviews regarding their implementation.

6.4.1 National Strategy for Ecologically Sustainable Development 1992

As Harding (1998) noted different countries developed their own definitions and goals for sustainable development. In Australia, the term ESD has been used as means to differentiate between interpretations of sustainable development as a strategy to sustain development. It includes an interpretation that also places an emphasis on ecological considerations. It emphasises the importance of both conservation of the natural environment and development. Australia developed its approach with the introduction of the NSESD, which addresses many key actions identified in Agenda 21 (Commonwealth of Australia, 1992). The Council of Australia Governments (COAG) agreed that all relevant policies and programs in the future should be developed within the ESD framework. The key objectives and guiding principles of NSESD are outlined below, followed by a summary of review undertaken by the Productivity Commission in 1999.

The *National Strategy for Ecologically Sustainable Development* (Commonwealth Australia, 1992) defines Ecologically Sustainable Development as "using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained and the total quality of life, now and in the future can be increased (Commonwealth of Australia, 1992, p 6)". ESD has been the accepted basis for management of natural resources in Australia (it applies to the manufacturing, mining, agriculture, forests, fisheries, energy production, energy use, tourism and transport sectors). The core objectives of NSESD are:

- to enhance individual and community well-being and welfare by following a path of economic development that safeguards the welfare of future generations;
- to provide for equity within and between generations; and
- to protect biological diversity and maintain essential ecological processes and life-support systems.

The guiding principles of NSESD are:

- decision-making processes should effectively integrate both long and short-term economic, environmental, social and equity considerations;
- where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
- the global dimension of environmental impacts of actions and policies should be recognised and considered;
- the need to develop a strong, growing and diversified economy which can enhance the capacity for environmental protection should be recognised;
- the need to maintain and enhance international competitiveness in an environmentally sound manner should be recognised;
- cost effective and flexible policy instruments should be adopted, such as improved valuation, pricing and incentive mechanisms; and
- decisions and actions should provide for broad community involvement on issues which affect them (Commonwealth of Australia, 1992 pp. 8-9).

Under NSESD, these guiding principles and core objectives were to be considered as a package, with a balanced approach where no objective or principle dominates over the others (Commonwealth of Australia, 1992 p. 9). The challenge for fisheries management agencies throughout Australia was to adopt a fisheries ecosystem management framework that would provide a more holistic and sustainable approach to management of aquatic resources. The strategic approach for enhanced decision-making by management authorities, resource users, and individuals was to be based on an understanding of consequences of actions. The elements considered necessary for ecosystem management included data collection and research on fish stocks and environmental factors; steps to address cross sectoral issues; capacity building through education; development of strategic management plans, framed within the principles of ESD; and rationalisation of fishing capacity in over-exploited fisheries (Commonwealth of Australia, 1992 p. 26).

These objectives were to ensure that fisheries management agencies worked within a framework of resource stewardship; developed national guidelines for the state of the aquatic environment reporting; and disseminated information on the principles of ESD to fisheries and the wider community. Governments were directed to adopt a fisheries ecosystem management approach, consistent with ESD principles, requiring, where necessary, amendment to legislation; development of fisheries management plans; prioritisation and co-ordination of scientific research; resolution of jurisdictional boundaries; involvement of fishing industries and other relevant stakeholders; the establishment of management advisory committees (MACs); and seeking to formalise international commitments (Commonwealth of Australia, 1992 pp. 26-29). These initiatives significantly changed the focus of fisheries management for all agencies. During the 1990s all Australian governments incorporated the goals and principles of ESD into new or amended fisheries Acts, although their approaches differed (as discussed above by the Australian Conservation Foundation).

Review of NSESD

The Productivity Commission (1999) report *Implementation of Ecologically Sustainable Development by Commonwealth Departments and Agencies, Inquiry report No.5* assessed how Commonwealth departments and agencies were applying ESD principles and objectives into policy making, and how they monitored, evaluated and reported on the implementation of ESD. The Productivity Commission was asked to make recommendations designed to further implement the objectives and principles of NSESD. The enquiry highlighted that the wide variation at departmental and agency levels in explicit (policies, programs, regulations) or implicit (taking account of ESD consequences as part of policy making) implementation of ESD (Productivity Commission, May 1999 p. xvii).

An important finding was the lack of clarity regarding ESD and what it meant for policy making. The role of government in ESD implementation was multi-faceted and multi-disciplinary in scope, and under these conditions co-ordination between agencies was important for policy development processes and decision outcomes. The integration of environmental, economic, and social considerations had not occurred in some cases, pointing to the inadequacy of existing tools. Reconciling multiple objectives was difficult, particularly when considering trade-offs between short and long-term objectives, and between different stakeholder values and preferences. Performance monitoring was considered a critical element and this had either not been undertaken routinely, or results had not been incorporated into policy or program revisions via feedback mechanisms. Lack of long-term considerations was often related to shortcomings in commitments to data collection; different data collection approaches; and limited co-ordination between agencies for data sharing. Natural resource management under ESD is complex and therefore requires a process of continuous improvement (Productivity Commission, 1999 pp. xvi-xxv).

The recommendations for improving ESD implementation by departments and agencies was through improving policy development processes and explicitly accounting for the environmental, economic, and social consequences of proposed policies and programs; improving co-ordination between Commonwealth departments, agencies, and other stakeholders; regular monitoring and review of policy initiatives; encouraging longer term strategic thinking; and developing a longer term commitment to monitoring. The suggested elements for best practice in policy making included:

- clear identification of the problem, including whether government action was warranted, and if so, why;
- specific and clear statement of objectives;
- consideration of alternative policy mechanisms;
- comprehensive identification and assessment of impacts for ESD, including short-term and long-term economic, environmental and social impacts;
- integrated decision-making;
- consultation with stakeholders;
- monitoring and evaluation; and
- ongoing review (Productivity Commission, 1999 pp. xxv-xxvi).

The government's response to the Productivity Commission focused on mechanisms to progress the implementation of ESD in the policy and operations of Commonwealth departments and agencies. In August 2001, a whole of government approach to the implementation of ESD was agreed to.

6.4.2 Australia’s Oceans Policy

Australia’s Oceans Policy was first introduced in 1998 and revised in 2005. Oceans Policy 1998 (Commonwealth Government, 1999a; Commonwealth Government, 1999b) set in place the framework for integrated and ecosystem-based planning and management for all of Australia's marine jurisdictions. At the core of the Oceans Policy was the development of Regional Marine Plans, referred to as marine bioregional plans (Department of the Environment and Heritage, 2006), based on large marine ecosystems, which are binding on all Commonwealth agencies; and the declaration and management of marine protected areas in Commonwealth waters. The state and territory governments exercise separate jurisdictions over their marine environment, declaring MPAs under their respective legislation. The *Marine Industry Development Strategy* (Australian Marine Industries and Sciences Council, 1997) and the *Australia’s Marine Science and Technology Plan* (The Marine Science and Technology Plan Working Group, June 1999) were companion documents to the policy, representing a long-term (ten to fifteen years) strategy and plan for integrated and innovative science and technology.

In 2005 the Australian Government brought its program of regional marine planning directly under Section 176 of the EPBC Act. The new plans were to be known as marine bioregional plans to reflect the part of the Act under which they were to be established. This initiative aimed to give a new impetus for the implementation of Australia’s Oceans Policy by streamlining the planning process and providing greater guidance about marine environment conservation priorities and the declaration of MPAs (Department of the Environment, Water, Heritage and the Arts (8 October 2009).

The Australian Government is committed to develop, by 2012 a network of Marine Protected areas that is representative of the provincial bioregions recognised in Commonwealth waters (as identified by the *Guide to the Integrated Marine and Coastal Regionalisation of Australia IMCRA version 4.0* (Commonwealth of Australia, 2006). DEWHA developed a policy document *Goals and principles for the establishment of the National representative systems of MPAs in Commonwealth waters* to refine the approach to identifying areas suitable for inclusion in the NRSMPA that are identified during the marine bioregional planning process (Department of the Environment and Water Resources, 18 December 2007).

Oceans Policy reviews

As discussed by Haward and Vince (2009) the Oceans Policy implemented by the Commonwealth and applied within the Commonwealth jurisdiction, has been a major initiative, but faced a number of challenges from the beginning. In 1997 a consultation paper *Australia's Oceans: new horizons* was launched for public comment. The state and territory governments responded positively to the paper but had concerns with regard to institutional arrangements, financial commitments and obligations. Discussions were held but these issues were not resolved. In 1998 the then Commonwealth Minister for the Environment indicated that Environment Australia would complete the final document without involving the states, and the final document emphasised that Oceans Policy was a Commonwealth initiative. Three reviews of the Oceans Policy were undertaken, *Review of the Implementation of Oceans Policy* (TFG International, 2002), *Oceans Eleven* (Smyth et al., 2003), and *Out of the Blue: an Act for Australia's Oceans* (Australian Conservation Foundation and the National Environmental Law Association, 2006). All the reviews noted that the Oceans Policy document did not represent an agreed position with the states and territories, and had not been endorsed by them. Australia's Ocean Policy is not legally binding, the regional management plans were to be the main mechanisms for delivery of Oceans Policy, but these had no standing under existing statutes and implementation relied upon agreements between ministers, agencies and Commonwealth and state jurisdictions. A recommendation was that the Australian Government should consider providing stronger legislative direction and institutional reform for the implementation of Oceans Policy (TFG International, 2002; Smyth et al., 2003; Australian Conservation Foundation and the National Environmental Law Association, 2006).

6.4.3 Environment Protection and Biodiversity Conservation Act 1999

The key objectives and principles of the EPBC Act are outlined below, and this is followed by several reviews relating to the first round of the fisheries strategic assessments under the Act.

The aim of the EPBC Act is to provide a framework for environmental protection and conservation of Australian biodiversity in Commonwealth, states and territories. The Commonwealth takes responsibility for leadership on the environment, and the states are responsibile for delivering on the ground resource management. The objectives of the Act are:

- to provide for the protection of the environment, especially those aspects that are matters of national environmental significance;
- to promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources;
- to promote the conservation of biodiversity;
- to promote a co-operative approach to the protection and management of the environment involving governments, the community, and other relevant stakeholders;
- to assist in the co-operative implementation of Australia's international environmental responsibilities; and
- to recognise the role and interests of Indigenous people, including the use of their knowledge in the conservation and ecologically sustainable use of Australia's biodiversity, with involvement of, and in co-operation with, owners of the knowledge (*Environemt Ptorections and Biodisversity (EPBC) Act 1999* Chapter 1, Part 1 Section 3.1).

Under the Act if an action will have, or is likely to have, a significant impact on a matter of national significance it requires approval from the Environment Minister; and may require an Environmental Impact Assessment. Some matters of national environmental significance related to the marine environment include Ramsar wetlands of international importance. Those of relevance to fisheries include Commonwealth marine environment; the fisheries strategic assessments; threatened species and ecological communities; and migratory marine species protected under international agreements (Department of the Environment, Water, Heritage and the Arts, 25 November 2009).

The EPBC Act requires all Commonwealth managed fisheries to undergo strategic assessments before new management arrangements are brought into effect, and for all fisheries (Commonwealth and states) with an export component to undergo strategic assessment to determine the extent to which management arrangements will ensure that the fishery is managed in an ecologically sustainable way. Part 10 of the EPBC Act relates to strategic assessment of fisheries; Part 13 relates to assessments regarding impacts on protected marine species; Part 13A relates to those fisheries requiring approval for the export of fisheries products (Department of the Environment, Water, Heritage and the Arts Fisheries and the Environment, 10 December 2009).

Reviews of the first round of strategic assessments under the EPBC Act 1999

The first round of fisheries strategic assessments aimed to identify the key risks in each fishery, and develop recommendations and conditions to address the risks in the short to medium-term, while also promoting a continuous improvement approach. Reviews of the first round of the strategic assessment processes and outcomes under the EPBC Act included a survey undertaken by the Marine and Coastal Community Network (MCCN), and a summary report by Barry (2006) as reported in WAVES vol. 12 (1) Spring 2006. The lessons learnt from the first round of assessments were discussed in Australian Fisheries Management Forum (AFMF) and Department of the Environment, Water and the Arts (DEWHA) forums, and recommendations for reassessments were presented for consideration by the Minister. A summary of these reviews is provided below.

The MCCN reviewed the first round of fisheries strategic assessment processes, through a survey that included a cross-section of fisheries stakeholders, including the Australian Government and all the state agencies. The purpose of the survey was to analyse outcomes from the first round of fisheries strategic assessments under the EPBC Act (Marine and Coastal Community Network, 2006 pp. 7-10). According to Barry (2006 pp. 1-2) the assessment process provided an improved understanding of the status of 130 individual commercial fisheries. It highlighted the diversity of fishery types and the different management regimes they operated under, and the different stages of development towards implementation of ESD and ecosystem-based management. A major issue that was identified was the lack of knowledge and information on the biology and status of some target, byproduct and bycatch species (and needs to be addressed). This included, for example, bycatch monitoring programs, reporting mechanisms for protected species interactions, and more appropriate spatial and temporal scales of fishery data. The process had been a challenge for both fishery management agencies in terms of preparing submissions against the guidelines, as well as for DEWHA in assessing fisheries submissions. Therefore, it was important to learn from the first round of assessments and incorporate these lessons into any re-assessment processes (Barry, 2006 pp. 1-2).

Australian Fisheries Management Forum: the lessons and possible future directions

Webb and Smith (2008) reported the outcomes of the Australian Fisheries Management Forum (AFMF) workshop in Melbourne in the *Review of the scope, assessment methods and management responses for fisheries ESD and EBFM in Australia.* The AFMF met in Sydney on 30 June 2005, to discuss and review the major issues raised regarding the first round of the strategic assessment process, and the lessons learned and future processes. This was followed by an AFMF and Department of the Environment, Water, Heritage and the Arts (DEWHA) workshop held in Melbourne on 12 May 2006 to discuss and develop a reassessment process for the second round of fishery strategic assessments.

At the Sydney forum the lessons learned from the first round of strategic assessments were discussed under the following headings: fishery agency submissions to DEWHA; the DEWHA assessment process; the Minister’s decisions and recommendations; and key issues (Webb and Smith, 2008). The purpose of the AFMF workshop in Melbourne was to discuss future assessments and recommendations from the first round of strategic assessments. The formation of the DEWHA working group was to assist DEWHA in the development of a reassessment process for the second round (and beyond) of fishery strategic assessments under the EPBC Act. The working group was responsible for responding to some of the issues, for example in providing more clarity for meeting the strategic assessment guidelines. A revised re-assessment approach was prepared for consideration by the Minister. The overarching objective of the proposed amendments was to maintain the Australian Government's ability to protect the environment, and in response to the issues raised above by providing a more effective, efficient and strategic process for stakeholders; reducing duplication in regulatory processes; increasing the flexibility within Act processes; reducing administrative and compliance costs; and increasing the effectiveness of the compliance regime (Webb and Smith, 2008 pp. 121, 125).

Following consultation with governments and environmental groups, a revised approach to the fishery assessment processes under the EPBC Act was approved by the Hon. Malcolm Turnbull, then Minister for the Environment and Water Resources in August 2007. The updated version of the *Guidelines for the Ecologically Sustainable Management of Fisheries* (the Guidelines) includes a revised streamlined process for reporting and submission requirements, for fishery assessments under the EPBC Act. The fishery assessments are conducted against the Guidelines which outline specific principles and objectives designed to ensure a strategic and transparent way of evaluating the ecological sustainability of fishery management arrangements (Department of the Environment, Water, Heritage and the Arts, 3 November 2009).

Guidelines for the ecologically sustainable management of fisheries, and the key principles and objectives are outlined below.

Principle 1

A fishery must be conducted in a manner that does not lead to over-fishing, or for those stocks which are over-fished, the fishery must be conducted such that there is a high degree of probability the stock(s) will recover**:**

- Objective 1: the fishery shall be conducted at catch levels that maintain ecologically viable stock levels at an agreed point or range, with acceptable levels of probability.
- Objective 2: where the fished stock(s) are below a defined reference point, the fishery will be managed to promote recovery to ecologically viable stock levels within nominated timeframes.

Principle 2

Fishing operations should be managed to minimise the impact on the structure, productivity, function and biological diversity of the ecosystem:

- Objective 1**:** the fishery is conducted in a manner that does not threaten bycatch species.
- Objective 2: the fishery is conducted in a manner that avoids mortality of, or injuries to, endangered, threatened or protected species and avoids or minimises impacts on threatened ecological communities.
- Objective 3: the fishery is conducted, in a manner that minimises the impact of fishing operations on the ecosystem generally.

(Department of the Environment, Water, Heritage and the Arts, 3 November 2009).

6.5 Australia's oceans and fisheries context: governance and management responses

In November 1979 Australia proclaimed an Australian Fishing Zone (AFZ) the area of sea from the coast out to 200 nautical miles offshore (1 nautical mile = 1.85 km). The Australian Fishing Zone (AFZ) is the third largest in the world, covering nearly nine million square kilometres. This also includes the waters surrounding the offshore territories of the Cocos Keeling, Christmas, Norfolk, Macquarie, Heard and McDonald Islands. Australians are obliged to conserve and manage the fisheries and other marine life within the AFZ. Foreign nations cannot legally fish within Australian waters without prior permission from the Government. On 1 August 1994, Australia declared an EEZ extending 200 nautical miles from its coastline. The declaration of the Australian EEZ was consistent with the actions taken by other maritime nations under the United Nations Convention on the Law of the Sea (UNCLOS). The AFZ and the EEZ differ in that, while the AFZ relates only to the use or protection of fisheries, the EEZ relates to all types of resources in the zone (e.g. fish, oil, gas, minerals, etc.). One other difference the AFZ does not apply to the Australia Antarctic Territory – the EEZ does. Under the EEZ regime, where the edge of the continental shelf extends beyond 200 nautical miles, Australia has the right to explore and exploit in this area, the non-living resources such as oil, gas and minerals, as well as sedentary fisheries species. The exploitation of non-living resources beyond 200 nautical miles is subject to a duty to share any profits with the International Seabed Authority, also established under UNCLOS (Rothwell and Haward, 1995).

Australia's ocean territories are rich in biodiversity, and due to Australia's island status and isolation from other continents many species are endemic. In the temperate south, about 80-90% of species of most marine groups are either endemic or restricted to this area, and in the tropical north about 10% of most groups are endemic. Australia's oceans span almost 60 degrees latitude from Torres Strait in the north to Antarctica in the South. Australia's oceans span all five temperature zones tropical, sub-tropical, temperate, polar, and polar (Zann, 1995). Australia has examples of a wide range of coastal and oceanic ecosystems, and their associated communities, habitat types and species. In Australia many of these ecosystems provide valuable ecosystem goods and services. Australia is one of 12 nations that are collectively responsible for more than 70% of the world's biodiversity, and Australia may be the most important single jurisdiction. However, much of this biodiversity remains undiscovered, especially species of outlying islands, continental shelves, shelf-edge canyons, and continental slopes and their overlying waters, all of which are difficult to sample and study. Many species are not well understood in terms of how their populations are maintained, or what environmental features are critical for their long-term survival (Ward and Butler, 2006 pp. 2-3).

6.5.1 Issues identified in Australia's State of the Environment reports

Australia has a legislative mandate for State of the Environment (SoE) reporting, in meeting its international requirements; and nationally under the EPBC Act (most states and territories of Australia also produce SoE reports). The independent 1995 State of the Marine Environment Report for Australia (Zann, 1995), was the first comprehensive description, of Australia's marine environment, outlining its uses and values; issues and threats; and its management. It was followed by the first State of the Environment Report 1996, the second was released in 2001 and the third in 2006. The SoE reporting objectives are to provide the public and decision makers with an understanding of, and information on, the condition of the environment; an early warning of potential problems; and reporting on the effectiveness of policy initiatives and management actions in response to issues.

Australian marine and estuarine environments and habitats were generally considered to be in good condition (State of the Environment Advisory Council, 1996). Where human settlement and land use was light coastal waters were often in good condition (Australian State of the Environment Committee, 2001). While there were no surprises or new issues since 2001, the need to resolve existing problems remained, and needed addressing in order to stem the slow decline of environmental quality (Beeton et al., 2006). To assist with the independence of the reporting process the Committee commissioned peer reviewed commentaries on each of the major themes; and current and emerging issues papers, which support the 2006 SoE, but were not formally part of it. Ward and Butler (2006) prepared the coasts and oceans theme commentary, which included a discussion on the important features of the oceans and coasts, and where data was available, commented on issues and trends, outlined pressures from the marine sectors, and highlighted the important issues. The overall status and issues as reported for 1996, 2001, and 2006, are summarised in table 6.5.1 below.

Table 6.5.1: The overall status and issues as reported in the State of the Environment reports for 1996, 2001, 2006.

	SoE 1996 Estuaries and the sea	**SoE 2001 coasts and oceans**	**SoE 2006 coasts and oceans**
Overall state	Although marine and estuarine environments and habitats were generally in good condition.	Where human settlement and land use was light coastal waters were often in good condition. Many of the issues were the same as those reported in 1996, and had improved very little and in some cases worsened.	While there were no surprises or new issues since 2001, the need to resolve existing problems remained, and needed addressing in order to stem the slow decline of environmental quality
Key findings			
Status of ecosystems	No common understanding of the ecosystems, their status and issues affecting them.	Remains limited, particularly the status of many marine species and habitats and the deep sea environment.	No comprehensive nationally consistent system for monitoring and measuring the condition and trends of coasts and ocean ecosystems and biodiversity, and cumulative changes
Development of Indicators to measure condition of coastal and marine waters	National ability to measure condition through a system of standard indicators not developed	Still considered necessary but required a national approach to data collection and reporting systems. This had not occurred or improved since 1996	The 2006 report was based on only 263 indicators from the original 500 due to lack of useful and measurable information. i.e. the coasts and oceans theme was more than 50% data deficient.
Key habitat concerns	Coral reefs of the north east coast and temperate seagrasses of southern Australia. Extensive clearing or serious decline in area, particularly seagrass (serious), mangroves, and saltmarshes. Invasive species	Further loss of coastal habitat has occurred due encroachment human settlements and growth in pressures due to tourism. Invasive species	Loss of critical habitats. The forecasts of climate change suggested increasing ocean temperatures, ocean acidification and sea level is rise and planning for adaptation to climate variability should be a priority. Invasive species.

Table 6.5.1 continued: The overall status and issues as reported in the State of the Environment reports for 1996, 2001, 2006.

	SoE 1996 Estuaries and the sea	SoE 2001 coasts and oceans	SoE 2006 coasts and oceans
Land/marine interface	Increasing coastal development, industry and urbanisation have resulted in reduced water quality; habitat destruction and modification; pollution (nutrient run off; contaminants) estuaries and near shore areas, with increasing incidence of algal blooms	Coastal population continues to expand and the use of coastal resources is increasing. Increased coastal development continued degradation of habitats, water quality issues . Pressures on coral reefs continue unabated from downstream effects of land use and other human activities.	Predicted that 42.3% of the Nowra to Noosa coastline could be urbanised by 2050 In most cases key coastal habitat types are still declining. Most visible indicator of coastal eutrophication are excess blooms of phytoplankton and benthic macroalgae, and loss seagrass beds.
Fisheries	Most commercial fisheries fully exploited management regimes are partially effective and improving; the effects of fishing on habitat and non-target species largely unknown. Seafood quality generally high.	Fishing occurs over the whole of Australia's marine environment. Stock status of many species incomplete. Summary of the status of all fish stock not possible. Few examples in which fisheries management can claim success in achieving regulatory goals. Recreational fishing sector large and widely dispersed. Traditional fishing important to indigenous peoples. IUU a growing problem .Seafood quality issues regarding heavy metals accumulation through the food chain, with highest impact in long lived fish, and contamination particularly for shellfish. The environmental effects of aquaculture activities not fully understood, some activities may adversely affect the marine environment.	Overall trends in the status of commercial fisheries resources and bycatch were negative. State fisheries mixed some appear to be stable others overfished, but no fully independent assessment of fish stocks or the fisheries. For Commonwealth fisheries over past 12yrs an increase in the of stocks overfished. Difficult find consistent data to demonstrate changes over time in stocks, populations and bycatch. State fisheries, some states assess status of fisheries, but assessment processes are different and nationwide assessment difficult. Substantial catches of fish and invertebrates from recreational fishing. Aquaculture is increasing. IUU an ongoing issue. In recent years change in emphasis from issues related to target species, to non target and ecosystems.

Table 6.5.1 continued: The overall status and issues as reported in the State of the Environment reports for 1996, 2001, 2006.

	SoE 1996 Estuaries and the sea	SoE 2001 coasts and oceans	SoE 2006 coasts and oceans
Key management issues	No integrated framework for management of marine and coastal systems. No integrated ecosystem based approach for management of marine resources	Environmental management was fragmented across institutions and between different levels of government, and not able to integrate across a range of scales	Lack of national systematic framework for monitoring and assessing key ecosystem features, resources and sector issues and detecting changes requiring a management response.
Knowledge gaps	Not enough available information to report on offshore areas distant from major population areas	Reliability, availability and quality key issue for reporting. Problems include gaps in primary data, lack of trend data for some variables, some data could not be aggregated and compared due to diversity of scales used	Gaps in primary data for marine environment. Understanding of the issues at a range of spatial and temporal scales is important for the development and assessment of governance and management responses

Complied from State of the Environment Advisory Council, 1996; Bowen et al., 1996; Australian State of the Environment Committee, 2000; Australian State of the Environment Committee, 2001; Barratt et al., 2001; Beeton et al., 2006; and Ward and Butler, 2006.

6.5.2 Climate change: an emerging issue

As outlined in the State of the Environment reports the impacts of climate change is a serious issue for Australia (Beeton et al., 2006). Climate change does not occur in isolation from the cumulative impacts and interactions with other environmental stressors and drivers. Climate change is an overarching issue that will affect all ecosystems and human systems in a complex and uncertain manner, where both the understanding of the problem and its solutions are still emerging. As discussed in Chapter 3 section 3.2.4 the environmental and biophysical impacts of climate change include the warming of ocean waters, sea level rise and acidification; changing weather patterns, with more extreme storm and cyclone events; changes in ocean currents and waves; chemistry changes in ocean waters; and in coastal areas erosion of the shoreline. These changes will have significant impacts on Australia’s unique marine ecosystems and habitats, including marine biodiversity, the coastal zone, and fisheries and aquaculture.

Biodiversity is one of the most vunerable sectors to climate change, with valued natural heritage areas such as the Great Barrier Reef under threat, as well as having implications for national reserve systems, including marine reserves and MPAs. In the coastal zone, domestic infrastructure and valuable marine industries are also threatened by existing coastal zone issues and climate change. For example Queensland's coral reefs of the Great Barrier Reef support established tourism and fisheries sectors. These and other marine industries such as fisheries and aquaculture are important in providing employment opportunities, export earnings and cultural and recreational activities. A number of initiatives in response to climate change and preliminary assessments have been undertaken as outlined in Table 6.5.3.

6.5.3 Australia's governance and management response

In response to the current issues as outlined in the SoE reports; the emerging climate change issues; and the requirements of NSESD 1992, Oceans Policy 1998 and the EPBC Act 1999, a number of national policy initiatives and strategies have been developed. Key national policy initiatives are summarised in Table 6.5.3 below, under the following headings biodiversity conservation; land-based activities, marine pollution and biosecurity; climate change; and sustainable resource use and fisheries. The details of those initiatives which relate to the marine environment and fisheries can be found at the Department of Agriculture, Fishing and Forestry and the Department of the Environment, Water, Heritage and the Arts web sites as follows:

- Department of Agriculture, Fishing and Forestry:
    - aquaculture
    - domestic fisheries
    - fisheris and the environment
    - illegal, unreported and unregulated fishing
    - recreational fishing

(Department of Agriculture, Fishing and Forestry, 14 August 2009).

- Department of the Environment, Water, Heritage and the Arts:
    - biodiversity conservation
    - coasts and oceans
    - Environment Protection and Biodiversity Conservation (EPBC) Act
    - import and export of wildlife
    - Caring for our country
    - Department of Climate Change

(Department of the Environment, Water, Heritage and the Arts, 5 February 2010).

Table 6.5.3: The key national strategies and policy initiatives

Biodiversity conservation (6.5.3.1)	Land based activities, marine pollution and biosecurity 6.5.3.2	Climate change (6.5.3.3)	Sustainable resource use fisheries (6.5.3.4)
Conservation National strategy for the Conservation of Australia's Biodiversity (Department of the Environment Sports and Territories1996) *Australia's biodiversity conservation strategy 2010-2020 consultation draft* (National Biodiversity Strategy Review Task Group March 2009) A national approach to addressing marine biodiversity decline (Marine Biodiversity Decline Working Group April 2008) *Caring for our Country: caring for our country outcomes 2008-2013* (Australian Government September 2008) **EPBC Act 1999** Threatened species under the EPBC Act (DEWHA 21 January 2009) Threatened ecological communities under the EPBC Act (DEWHA 6 April 2009) Key threatening processes under the EPBC Act (DEWHA 3 December 2009) Recovery plans (DEWHA 23 November 2009) Threat abatement plans (DEWHA 18 November 2009) Migratory species (DEWHA 20 January 2010) Wildlife trade and conservation (15 February 2010) **NRSMPA** *Guidelines for Establishing the National Representative System of Marine Protected Area*s (ANZECC 1998) *The strategic plans of action for the NRSMPA: a guide for action by Australian Governments* (ANZECC 1999) A socio-economic impact assessment toolkit: a guide to assessing the socio-economic impacts of	**Land based activities** Australia's national programme of action for the protection of the marine environment from land-based activities (Natural Resource Management Ministerial Council October 2006) National cooperative approach to Integrated Coastal Zone Management (ICZM): framework and implementation plan ((Natural Resource Management Ministerial Council 2006) National strategy for the management of coastal acid sulphate soils initiative (National Working Party on Acid Sulphate Soils January 2000) **Marine pollution** *Environment Protection (Sea Dumping) Act 1981* National Pollutant Inventory Guide Version 5.1 (DEWHA February 2010) Impacts of plastic debris on Australian marine wildlife (C& R Consulting 19 June 2009) **Biosecurity** The National System for the Prevention and Management of Marine Pest Incursions (4 May 2009) Intergovernmental Agreement on the National System for the Prevention and Management of Marine Pest Incurions (DEWHA 15 April 2005) **Bioregional planning** *Marine bioregional planning: a new focus for Australia's marine planning* (DEWHA 2006) Bioregional plans: South-west; North-west; North; East; and South-west (DEWHA 8 October 2009) Goals and principles for the establishment of the NRSMPA in Commonwealth waters (DEWR 18 December 2007) Guidance on achieving comprehensiveness, adequacy, and representativeness in the Commonwealth waters component of the	Austrlian climate change science: a national framework (Department of Climate Change 2009a) National climate change adaptation framework (Department of Climate Change 13 April 2007) Climate change risk and vulnerability: promoting an efficient adaptation response in Australia (The Allen Consulting Group March 2005) Climate change: an Australian guide to the science and potential impacts (Pittock 2003). **Biodiversity** Australia's biodiversity and climate change: a strategic assessment of the vulnerability of Australia's biodiversity to climate change (Biodiversity and Climate Change Expert Advisory Group 2009) Biodiversity conservation research in a changing climate (Hilbert et al. 2007) National biodiversity and climate change action plan 2004-2007 (Natural Resource Management Ministerial Council 2004) **Parks and reserves** Implications of climate change for Australia's World Heritage Properties: a preliminary assessment (Australian National University 2009) Implications of climate change for Australia's National Reserve System: a preliminary assessment (Dunlop and Brown 2008) *The impacts and management implications of climate change for the Australian Government's protected areas* (Hyder Consulting Pty Ltd. March 2008) Climate change and the Great Barrier Reef: a vulnerability assessment (Johnson and Marshall 2007) **Coastal zone** *International assessment of the vulnerability of the*	**Commercial fisheries (Commonwealth and states)** Offshore constitutional settlement: a milestone in co-operative federalism (Australian Government Attorney-Generals Department 1980) Under the *EBPC Act 1999* Commonwealth and State commercial fisheries, accreditation of management plans; independent fisheries assessments for all export fisheries; and WTO approvals for export fisheries (DEWHA 29 Janauary 2010) National policy on fisheries bycatch (Ministerial Council on Forestry, Fisheries and Aquaculture August 1999) *National Plan of Action for the conservation and management of sharks* (Shark Advisory Group and Lack, May 2004), *National strategy to address interactions between humans and seals: fisheries, aquaculture and tourism* (The inter-governmental National Seal Strategy Group 2007) *Threat abatement plan 2006 for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations(*Australian Antarctic Division 2006) Australian national plan of action to prevent, deter and eliminate illegal, unreported and unregulated fishing (DAFF July 2005) **Recreational fishing** The national recreational fishing policy (National Recreational fisheries Working Group December 1994) Recreational Fishing Industry Development Strategy (RFIDS) under development (DAFF 20 February 2009) **Aquaculture** National aquaculture policy statement (DAFF 29

MPAs (Bureau of Rural Sciences 2005) Progress in implementing the NRSMPA (National marine Protected Areas Working Group April 2008) *Guidance on achieving comprehensiveness, adequacy, and representativeness in the Commonwealth waters component of the NRSMPA* (The Scientific Review Panel for the NRSMPA 20 February 2006)	NRSMPA (The Scientific Review Panel for the NRSMPA 20 February 2006) *A guide to the Integrated Marine and Coastal Regionalisation of AustraliaIMCRA version 4.0* (Commonwealth of Australia 2006)	*coastal zone to climate change, including an Australian perspective* (Abuodha and Woodroffe 2006) Climate change risks to Australia's coast: a first pass national assessment (Department of Climate Change 2009b) Vulnerability to climate change of Australia's coastal zone: analysis of gaps in methods, data and system thresholds (Voice et al. 2006) Variability and trends in the Australian wave climate and consequent coastal vulnerability (Hemer et al. 2008) **Fisheries** Implications of climate change for Australian fisheries and aquaculture: a preliminary assessment (Hobady et al. 2008) The impacts of climate change on Australian marine life (Hobday et al. 2006a,b,c) Climate change and Australian fisheries knowledge imperatives and research opportunities (Campbell 2007) *Assessment and reporting of the ecologically sustainable development of Australian aquaculture : an industry perspective* (Buckee, J. September 2004)	January 2008) *Best Practice framework of regulatory arrangements for aquaculture in Australia* (Aquaculture Committee of the Marine and Coastal Committee February 2005) Sustainable aquaculture: development strategy (National Aquaculture Council July 2007) **Indigenous Australians and sea country** A national aquaculture development strategy for Indigenous communities in Australia (Lee and Nel March 2001) Living on saltwater (DEWHA 14 March 2008) Sea country plans (DAFF 10 October 2008)

6.6 Multi-level and multi-institutional governance and management: issues of interplay and fit

Australia is a federation under three levels of government the Commonwealth, state and territories, and local governments; and the two main agencies responsible for oceans and fisheries are Department of Agriculture, Fisheries and Forestry (DAFF) and Department of the Environment, Water and the Arts (DEWHA). The multi-level and mutli-institutional governance and management arrangements are outlined in Figure 6.5.2 below, and will be discussed briefly.

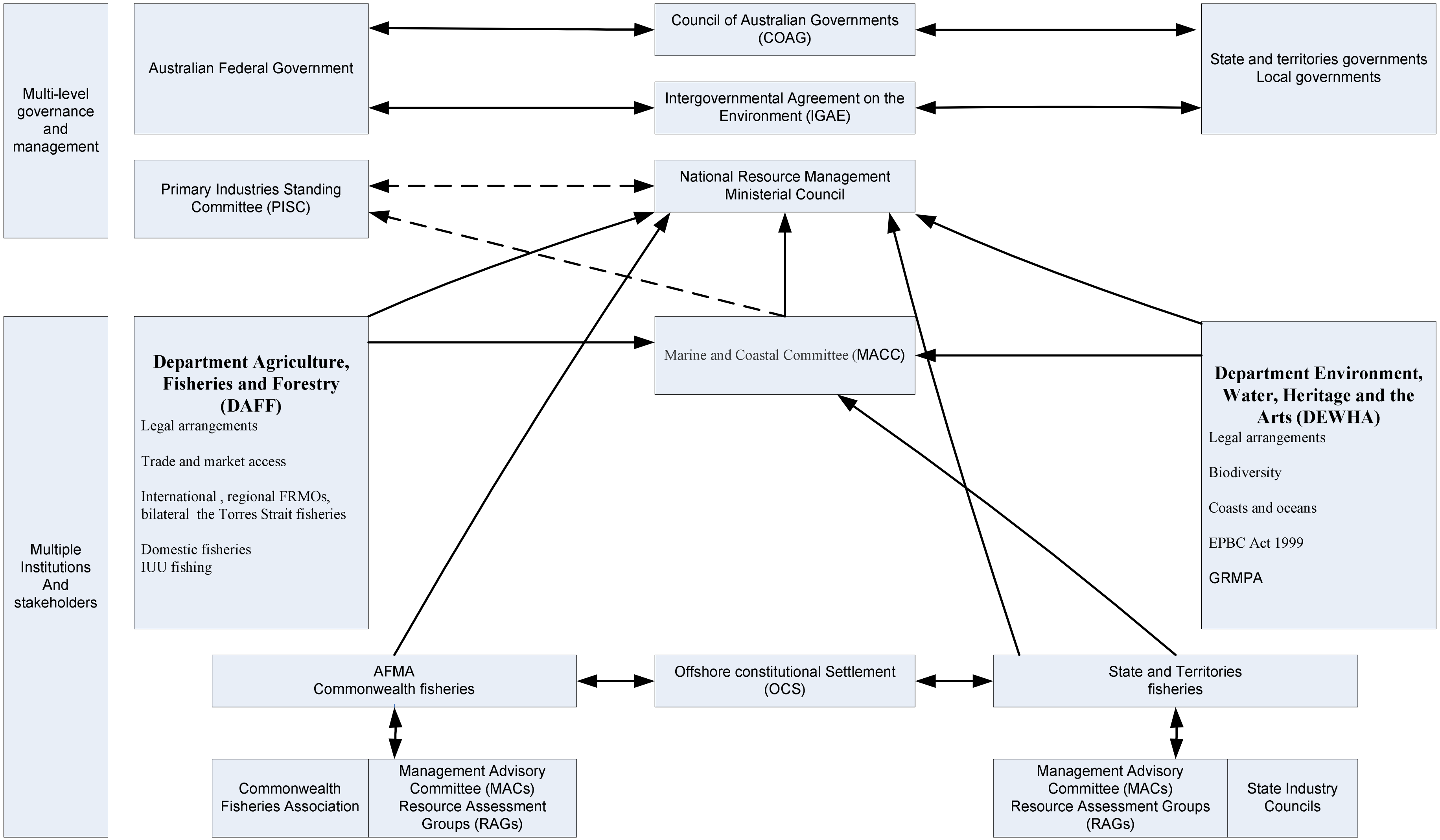


Figure 6.5.2: Multi-level and multi- institutional governance and management.

6.6.1 Multi-level governance and management

The respective environmental roles and responsibilities of the Commonwealth, states and territories, and local governments are delineated in the Intergovernmental Agreement on the Environment (IGAE). The governance and management of fisheries is shared between the Commonwealth and state and territory governments, and the jurisdictional roles are formalised under the Offshore Constitutional Settlement (OCS). Within this framework there are a range of other formal consultation and participatory decision-making arrangements such as the Council of Australian Governments (COAG) and Ministerial Councils and Committees for governance and management of Australia's oceans and fisheries. These are briefly outlined below:

- *Intergovernmental Agreement on the Environment:* the purpose of IGAE is to provide a co-operative approach for the development of environmental policies, management of environment issues, and to specify co-operative arrangements on specific issues. The agreement has been endorsed and signed by all levels of government. It deals with situations where both Commonwealth and state and territory interests are involved. It aims to improve consultation processes between all levels of government with regard to the entering and signing of international instruments and agreements on the environment (Department of the Environment Water, Heritage and the Arts, 1 May 1992).

- *Offshore Constitutional Settlement:* under the OCS generally the states are responsible for management of activities from the low water mark to three nautical miles offshore, and title to its adjacent seabed. The Commonwealth is responsible for water from three nautical miles to the 200 nautical mile Economic Exclusive Zone boundary declared in August 1994. For reasons of practicality and efficiency, arrangements which allocate the respective responsibilities on a different basis may be agreed to for particular fisheries. The Commonwealth (with the relevant states and territories) also has a leading role in managing shared fish stocks, straddling fish stocks, and highly migratory species, through relevant bilateral, regional and international fisheries management organisations. Fisheries OCS arrangements are in place with all states (Australian Government Attorney-Generals Department, 1980; Foster and

Haward, 2003; Haward, 1989; Australian Government Attorney-Generals Department, 3 September 2009).

- *Council of Australian Governments*: COAG is the peak intergovernmental forum in Australia. COAG comprises the Prime Minister, State Premiers, Territory Chief Ministers and the President of the Australian Local Government Association (ALGA). The then Prime Minister, Premiers and Chief Ministers agreed to establish COAG in May 1992. It first met in December 1992. The Prime Minister chairs COAG, and the Secretariat is located within the Department of the Prime Minister and Cabinet. The role of COAG is to initiate, develop and monitor the implementation of policy reforms that are of national significance and which require co-operative action by Australian governments. COAG meets on an as needs basis, or alternatively, COAG may settle particular issues out-of-session by correspondence. The outcomes of COAG meetings are contained in communiqués released at the end of each meeting. Where formal agreements are reached, these may be embodied in Intergovernmental Agreements (Council of Australian Governments, 5 November 2008).
- *Ministerial councils and committees*: Commonwealth-State Ministerial Councils and fora facilitate consultation and co-operation between the Australian Government and state and territory governments in specific policy areas. The major role of these Ministerial Councils is to better integrate Australia's conservation and sustainable production objectives. There are four major advisory committees that underpin the work of the Natural Resource Management Ministerial Council (NRMSC). These are the Natural Resource Policies and Programs Committee; Marine and Coastal Committee; National Biosecurity Committee; and the National Water Initiative Committee. The Marine and Coastal Committee advises and supports the NRMSC (and Primary Industries Standing Committee, as appropriate on issues of national significance relating to the conservation and ecologically sustainable development of marine and coastal ecosystems and resources (Australian Government, 15 February 2010).
- *Australian Fisheries Management Forum*: the Australian Fisheries Management Forum (AFMF) is a consultative committee that comprises the heads of all

fisheries management agencies. It aims to ensure high level inter agency collaboration of issues of mutual benefit and interest. It progresses fisheries issues to the NRMC through the Marine and Coastal Committee. Although AFMF is an informal forum it has the potential for contributing towards better integration of fisheries management across jurisdictions (McPhee, 2008 p. 121).

6.6.2 Oceans and fisheries multiple institutions and stakeholders

At the Commonwealth level the two main national institutions responsible for oceans and fisheries policy and planning are the Department of Agriculture, Fisheries and Forestry (DAFF) and the Department of the Environment, Water and the Arts (DEWHA).

Roles and responsibilities of the Department of Agriculture, Fisheries and Forestry

DAFF policies and programs encourage and support sustainable natural resource use and management. DAFF develops and implements policies and programs that ensure Australia's fisheries are competitive, profitable and sustainable. It supports Australia's fisheries and aquaculture through research; quarantine; fish health and food safety programs; market access and trade negotiations; business development and management assistance; and policy development. DAFF administers the international requirements of UNLOSC; UN Fish Stocks Agreement; FAO compliance agreement; and the FAO Code of Conduct for Responsible fishing; and national legislative arrangements under the *Fisheries Management Act 1991*; *Fisheries (Management) Regulations 1992; Fisheries Administration Act 1991; Fisheries (Administration) Regulations 1992; Torres Strait Fisheries Act 1984; and Torres Strait (Fisheries) Regulations 1985*. The DAFF Fisheries Division is responsible for the administration of fishery and fishery related program areas and policy initiatives. At the international level as discussed above these include international fisheries; involvement in Regional Fisheries Management Organisations (RFMOs); and Illegal, Unreported and Unregulated (IUU) fishing. At the national level the program areas include fisheries market access and trade; domestic fisheries; fisheries environment; recreational fishing; and aquaculture. Recent reviews of Commonwealth managed fisheries has resulted in a number of policy initiatives. These initiatives for Commonwealth fisheries managed by AFMA will be discussed in more detail in Chapters 7 and 8 (Department of Agriculture, Fisheries and Forestry, 14 August 2009).

Roles and responsibilities of the Department of the Environment, Water, Heritage and the Arts

The DEWHA develops and implements national policy, programs and legislation to protect and conserve Australia's environment and heritage and to promote Australian arts and culture. These activities are managed under the following program areas: Atmosphere; Biodiversity; Coasts and marine; Heritage; Land; Parks and reserves; Human settlements; Arts and culture. DEWHA administers environment and heritage laws, including the *Environment Protection and Biodiversity Conservation Act 1999;* and manages the Natural Heritage Trust; and represents the Australian Government in international environmental agreements related to the environment and Antarctica. The broader environmental considerations that are related to, or may be of benefit to fisheries directly or indirectly are Biodiversity (including invasive species; migratory species; threatenened species and communities; and wildlife trade); and Coasts and marine (including marine bioregional planning; marine pollution; fisheries and the environment); Great Barrier Reef; Marine Protected Areas; and marine species; Indigenous Australians; and the National Resource Management activities Caring for our Country. Those directly related to fisheries are the fisheries strategic assessments under the *EBPC Act 1999* (Department of the Environment, Water, Heritage and the Arts, 5 February 2010).

Fisheries agencies

There are different institutional models for fishery agencies in Australia. The Australian Fisheries Management Authority (AFMA) was a statutory authority until 2008, and is now a Commission, with responsibility for the management of Commonwealth fisheries. Western Australia is now the only State with a stand alone fisheries department, with the other states managing fisheries within respective Departments of Primary Industries (McPhee, 2008 pp. 64-65). It should be noted that the Great Barrier Reef is managed by the Great Barrier Reef Management Authority under separate legislation. The Great Barrier Reef Marine Park Authority (GBRMPA) is the principal adviser to the Australian Government on the control, care and development of the Great

Barrier Reef Marine Park. The GBRMPA is responsible for the management of the marine park and undertakes a variety of activities including developing and implementing zoning and management plans; environmental impact assessment and permitting of use; research, monitoring and interpreting data; providing information and educational services; and marine environmental management advice. The GBRMPA is structured to focus on the major issues relating to the Great Barrier Reef. These are fisheries; tourism and recreation; water quality and coastal development; conservation, heritage and indigenous partnerships; and climate change (Great Barrier Reef Marine Park Authority, 2010).

Stakeholders and consultation

The majority of conservation legislation at both Commonwealth and state levels provides for public notification and consultation; third party rights to comment; appeal and to bring injunctions; and also provides for referral and consultation between different government sectors. Consultation regarding fisheries management arrangements with the relevant stakeholders is an important feature of Australian fisheries management agencies. AFMA has a responsibility to consult with all stakeholders on fisheries resources when making management decisions regarding Commonwealth fisheries. This is achieved through the Management Advisory Committees (MACs) for each major Commonwealth managed fishery. State and territory fisheries also use MACs or similar groups such as Fisheries Management Committees (FMCs) or Fisheries Advisory Committees (FAC). Another example is the Western Australian ESD Fisheries Reference Group. Commercial and recreational fishers are often represented by peak bodies (McPhee, 2008 pp. 108-114).

6.7 Discussion

Australia engages in international fisheries issues in order to promote sustainable fisheries management practices world-wide, and to achieve long-term access to regional migratory and straddling stocks important to Australian fisheries. Australia's international role was discussed in Section 6.2. Some important aspects regarding regional and bilateral roles and responsibilities are discussed below. This is followed by a discussion of Australia's policy framework under ESD and EBFM principles, and the development of governance and management initiatives in response to ecosystems and human system issues in Australia.

6.7.1 Regional management

The 1995 United Nations Fish Stocks Agreement (UNFSA) provides a framework for creating Regional Fishery Management Organisations (RFMOs) for the governance and management of straddling and highly migratory fish stocks. Reviews of the governance and management arrangements, and performance of many RFMOs, identified that the broader international expectations had not been met (as discussed in Chapter 4 Section 4.3.2). As Miller (2007) highlights agreements under some RFMOs have provided a basis for satisfactory fisheries harvest management, while others have a history of recurring disputes, ineffective control of harvesting activities, inability to maintain stable co-operation, and degradation of shared resource stocks. According to Miller (2007) another challenge for RFMOs relates to climate driven changes in the productivity, migratory behaviour, or catchability of the fish. Such impacts may result in incentives for opportunism and create other management challenges. Some of these issues are illustrated in examples of RFMOs governing tuna fisheries as provided in box 6.7.1 below.

Box 6.7.1: Tuna fisheries governance

Tuna’s are highly migratory making them susceptible to fishing pressure from multiple nations, including nations not party to cooperative fishing agreements. Commercial fisheries for tropical skipjack, yellowfin and bigeye tuna have developed rapidly in both the Western and Central Pacific and Indian Oceans since the mid 1980s. Most of the expansion was from distant water fishing nations (DWFNs) using modern purse seine or longline gear. The fisheries involve two distinct types of players, coastal/island nations that own part of the available fishing grounds, and DWFNs which own much of the modern harvesting capital, although some coastal nations such as Indonesia and the Philippines are major harvesters in their own right. Most of the productive fishing grounds in the Western and Central Pacific Ocean are comprised of the EEZs of island nations with only small patches of international waters in the equatorial band in which most of the tropical tuna harvest occurs. In contrast, for the Western Indian Ocean there are large expanses of equatorial international waters broken up by only a small number of island nations EEZs.

In the Western and Central Pacific prior to the expansion of commercial tropical tuna fisheries, Japan was the only significant DWFN in the region and in playing one island nation off against another was able to secure favourable terms of access (Miller 2007 p. 62). As more countries entered the fishery there has been increased competition for access to the richest fishing grounds. Some of the Pacific Island Countries (PICs) recognised potential payoffs in coordinating their negotiating positions on access fees. The Parties to the Naru agreement established and specified the minimum terms of access. The Pacific Forum Fisheries Agency (FFA) has played an important negotiating role in a multilateral access treaty with the United States. In other fishing access negotiations coordination among Pacific fishing nations has been less successful resulting in disparities in access fees and competition between island nations to attract foreign fleets, with some DWFNs actively encourage this competition in order to secure more favourable terms of access. According to Miller (2007) analysts argue the impediments to collective action in this region are a result of divergent interests of member nations, but not all are equally endowed with tuna resources. Those nations located close to the equator and west of the dateline have better access to tuna resources than those located east of the dateline or farther north or south of the equator. Although in El Nino years, the latter group, have had sporadic access to abundant tuna resources, and this presents them with a significantly different relationship to the resource, than the former group where tuna are almost always abundant. At the second meeting of the Western and Central Pacific Fishery Commission (WCPFC) in December 2005 the members adopted a resolution on conservation and management measures for the yellowfin and bigeye tuna based on limiting and allocating effort rather than catch per se, but it does not encompass the entire area into which harvesters are likely to move.

The management challenges in the Indian Ocean are even more difficult because a much larger proportion of the productive tuna habitat is in international waters. Climate variability drives seasonal changes in the location of the most productive fishing grounds, which lead to changes in abundance and catchability that are not well understood. This uncertainty has made it difficult for scientists to develop management advice that might provide a basis for a cooperative approach to harvest limits or allocations. As the purse seine harvest has expanded in the region in recent years it appears that most of the tuna harvested are captured in international waters, rather than within the EEZs of Indian Ocean nations. DWFN fleets pay access for 67,000 ton of harvest out of a total Western Indian Ocean purse seine harvest of 250,000 ton. The ability of Western Indian Ocean coastal nations to extract access fees is limited due to the ready availability of tuna in nearby international waters; the high mobility of the international purse seine fleet, and its ability to track climate driven changes in tuna concentrations. The coastal nations have therefore focused on benefits from providing port services to foreign fleets, and they compete amongst themselves to supply these services. The IOTC primarily acts as a coordinator of research and data collection, rather than as an active manager of the fisheries in the region. There is little evidence of cooperation or affective coordination between Indian coastal nations in dealing with DWFNs. This weakness of the Indian Ocean Tuna Commission (IOTC) may have contributed to the rapid growth of IUU harvesting in the region. However, the commission is working to strengthen its ability to track tuna harvesting activities and to control tuna harvests in the Indian Ocean.

(Miller, 2007)

There are considerable challenges for RFMOs in governing and managing the harvest of straddling and highly migratory tuna fish stocks. For example, over-fishing of the southern bluefin tuna is continuing to occur in the Commission for the Conservation of Southern Bluefin Tuna (CCSBT) region. Within the CCSBT there has been a long history of diverging opinions regarding the interpretation of scientific advice; and disagreements over setting of the total allowable catch (TAC). A proposed management procedure has been suspended due to the identification of long-term under reporting of catches (see Chapter 4 Section 4.3.2). While Australia is party to, and an active member of, the IOTC, WCPFC and CCSBT, its influence in resolving these issues (as discussed in Box 6.7.1) within a reasonable timeframe is limited.

6.7.2 Bilateral arrangements

Vince (2007) notes that many of the fishers that illegally fish in the northern part of Australia's AFZ are Indonesian. There are a number of reasons for the increase in IUU fishing by Indonesia fishers. The Indonesian fish stocks have been depleted; the high market prices for some targeted species; and fishers are unable to make a living from legal fishing operations. There are also institutional factors as a result of inconsistencies and loopholes in the current international legal framework. In 1974 Australia entered into a Memorandum of Understanding (MoU) with Indonesia which recognised the traditional Indonesian fishers (who fished these waters prior to English settlement in Australia). The MoU specified an area of ocean called the MoU Box where traditional fishing within the Australian Fishing zone (AFZ) is permitted. The MoU enables Australia to manage access in AFZ waters, and for Indonesia it enables traditional fishers to continue their customary practices. In 1989 the guidelines were amended in the MoU to recognise the 200 nautical mile fishing zones. It should be noted that the Indonesian fishermen fishing in the MoU Box are not subject to Australian fisheries law.

Of concern to Australia are the high levels of over-fishing of species such as shark where the fins are taken and the remainder is discarded. According to Vince (2007) it has become evident that these species have been fished through non-traditional, illegal methods, and are now considered to be a well organised commercial activity. In February 2006 the Australian and Indonesian Ministers met to discuss illegal fishing in

Australia’s northern waters and agreed upon joint naval patrols in this area. While the Indonesian Government is interested in eradicating IUU in the MoU Box, Australian officials are conscious of the level of actual commitment that will eventuate from the bilateral discussions. As the decisions made at the highest level of government in Indonesia are not always implemented as intended and Indonesian law enforcement and government agencies are, widely considered to often be corrupt and ineffective. Australia is limited in the way it can assist Indonesia with its domestic problems, but must also be considerate of other policy issues that may affect the bilateral relationship.

In the 2006 Federal Budget, the Australian Government announced a range of new measures to combat illegal fishing in Australia’s northern waters. Under an integrated whole-of-government plan, agencies such as AFMA, Customs, Australian Quarantine and Inspection Service and Defence were provided with the resources to respond to increased risks of illegal, unregulated and unreported (IUU) fishing. As part of the package, AFMA works with Customs, AQIS and Defence through Border Protection Command which has responsibility for co-ordination and control of enforcement responses to illegal foreign fishing (Norwood, 2008 pp.11-12). In 2007/08 the number of illegal foreign fishing apprehensions was 125, and 27 in 2008/09, a significant reduction from 367 apprehensions in 2005/06. The number of illegal sightings has also decreased. Compared with the previous three years incursions are now occurring on the outer range of the AFZ and beyond. A number of activities have contributed to the success of the program including on-the-water enforcement, activities within Indonesia to prevent illegal fishing and co-operation between Australia and other nations to combat IUU on a regional basis (Australian Fisheries Management Authority, Autumn 2009 p.51).

Australia signed a co-operative treaty on enforcement of fisheries laws between the governments of Australia and France. The treaty formalises co-operative enforcement action against IUU fishing vessels, undertaken by joint patrols of the French and Australia in the Southern Ocean exclusive economic zones and territorial seas. The Co-operative Fisheries Enforcement Treaty builds on the Australia-France Surveillance Treaty that came into force on 1 February 2005. Most French patrols have Australian fisheries and customs officers onboard, and French officials are also onboard the Australian patrol vessel, the Oceanic Viking. Under this new agreement, Australian officers on French patrol vessels can apprehend illegal fishing vessels in Australia's waters around the Heard Island and McDonald Islands. Likewise French officers on board Australian patrol vessels can apprehend illegal fishing vessels operating in French waters (Australian Fisheries Management Authority, September 2006 p. 12).

6.7.3 Australia's ESD and EBFM national policy framework

The last decade has seen increasing attention on institutional arrangements and policy outcomes in Australia (Haward and Vince, 2009). Australia has responded to the international agreements it is party to, and incorporated the requirements of these into the national governance and management arrangements. Australia has adopted ESD and EBFM as a whole of government and management approach to oceans and fisheries. The three main policies that provide a framework for oceans and fisheries governance and management are the NSESD, Oceans Policy and the EPBC Act. The NSESD was developed as an accepted basis for the management of natural resource sectors including fisheries. Under ESD principles the environmental, economic and social dimensions are required to be included in governance and management arrangements and decision-making. The original intent of Oceans Policy was to promote ecologically sustainable development, an integrated approach to sectoral management, and protection of marine biodiversity, but under the revised arrangements the focus is on the environmental dimension, particularly with regard to conservation and the declaration of Marine Protected Areas (MPAs). Although the EPBC Act encompasses ESD principles, the strategic fisheries assessments focus on the environmental dimension, with minimal or no consideration of the economic and social dimensions. Thus, across all three policy areas, there is a tension between the intent to consider the environmental, economic and social dimensions, but in practice only the environmental dimension is considered in governance and management actions. The major ecosystem and human system issues have been identified, and a range of national policy initiatives have been developed in responses to these issues, as discussed in Section 6.4.5.

Overall the national governance initiatives appear to deal with the issues and align with the government's stated policy agenda. The various policy reviews and the SoE reports, however, indicate that the stated objectives are not being met in practice. A number of policy reviews (NSESD, Oceans Policy and EBPC Act) and performance assessment reports (State of Environment Reporting) point to issues of interplay and fit in terms of institutional and jurisdictional roles and responsibilities. While there have been reviews of selected individual policies that have identified particular issues or highlighted shortcomings, there has not been an overall review of the suite of policies in terms of evaluating the effectiveness, comprehensiveness, consistency, and coherence of these policies in response to the issues; the application and implementation within and across institutions; and between the different levels from national to local levels. An overall review would be useful in identifying where the issues of fit and interplay occur, and this understanding could facilitate a means of over-coming and resolving these issues. The reviews that have been undertaken do, however, point to the source of some of the problems. Of particular value would be how the jurisdictional roles and responsibilities between the different levels of government and across government institutions and agencies, affect the implementation of policy and policy initiatives. Australia is managed under three levels of government and there are many differences in legislative provisions and administrative arrangements between each of them. For example, despite state government attempts to legislative reform, coastal zone management remains affected by sectoral based legislation, which has contributed to fragmented and dispersed management arrangements. Another common theme throughout SoE reports, is the influence of jurisdictional roles and separate responsibilities between the Commonwealth and state and territory governments. Examples of these issues relate to bioregional planning, spatial planning and MPAs, and fisheries are discussed below.

Bioregional planning

The goal of Oceans Policy was to provide a national framework for an integrated ecosystems-based management approach to oceans planning and management, and for managing marine sectors (including fisheries), through bioregional plans based on large marine ecosystems. This approach was considered particularly important in managing cumulative impacts. The formulation of the original policy envisaged that Regional Marine Plans (RMPS) would propose allocations of ocean resources, delivered through existing responsible sectoral management arrangements, using multiple use principles to generate income and employment, and optimising long-term benefits to the community. As outlined by the Australian Conservation Foundation (2005), in Australia there is a large number of different sectoral based legislation. This in itself demonstrates a barrier to multiple use management, as there are numerous layers of administration and organisations which may need to be consulted within any one project or usage of a marine area. Further, the lack of an overarching management framework for the multiple and competing uses of the oceans makes it difficult to resolve competing priorities.

The effectiveness of the revised bioregional planning has been limited as there is still not an agreed position between the Commonwealth and the states, and even under the revised approach, this is still likely to remain an issue. Many ecological processes work across both the state and Commonwealth jurisdictions, and the Australian Government aims to work co-operatively with them in developing and implementing the new plans. The new approach and the shift toward bioregional plans have moved Oceans Policy away from its original intent. The RMPS would be the primary mechanism to provide an integrated approach to Australian ocean management, with a focus on economic and social, as well as environmental values, but this has proved difficult. The revised bioregional plans have a narrower focus than the previous plans with a greater emphasis on conservation and on the identification and declaration of MPAs as part of National Representative System of Marine Protected Areas (NRSMPA). This may result in many stakeholders perceiving that Oceans Policy now has an environmental and conservation focus, although under the EPBC Act a bioregional plan may include provisions for economic and social values (Haward and Vince, 2009 p. 9).

Coastal zone management

As outlined in the State of the Environment reports many of the marine ecosystems and critical habitats in the coastal zone are continuing to deteriorate due to land-based activities and coastal development. Coastal strip development through incremental extension of Australia’s existing urban areas is a threat to the temperate coast and tropical systems near existing population centres. There is a population migration from the main cities to smaller coastal settlements. Although urban development has slowed, it is predicted that 42.3% of the Nowra to Noosa coastline could be urbanised by 2050. The impact of continued urban expansion together with its attendant impacts for water quality in combination with nutrients, chemicals and sediments from agricultural catchments could become a serious issue for coastal species, habitats and ecosystems.

As well as creating localised and increasing pollution haloes around these coastal areas (Beeton et al., 2006; Ward and Butler, 2006).

Climate change and the rise of sea levels will affect coastal habitats and ecosystems and this together with changes in weather patterns will also impact human system infrastructure; marine sectors including fisheries; and communities in the coastal zone. An integrated coastal zone management approach is, therefore, important in dealing with climate change and the ecosystem issues and economic and social dimensions. The coastal zone systems are inherently diverse, complex, dynamic, and vulnerable and this requires the governing system to be concerned with the day to day and practical aspects and the institutional framework, which may not be easily transferable from one context to another (Jentoft, 2007). As discussed by Zagonari (2008) integrated coastal zone management is a continuous decision-making process aimed at maintaining, restoring, or improving specified qualities of coastal ecosystems and the associated human societies. Integrated coastal management systems need to be sustainable over long periods of time; be adaptable to conditions that often change rapidly; and initiatives must provide mechanisms which encourage or require particular forms of resource use, and collaborative behaviour among institutions and user group.

These coastal zone issues have the potential to impact the commercial wild caught, aquaculture, recreational and charter fishery sectors. For commercial fisheries, coastal zone habitats are important for many target species during their life history stages, and impacts on critical habitats may affect fish production and abundance. Aquaculture is sited within the coastal zone, and water quality is an important requirement for the production of farmed fish, and the safety and quality of fish products (free from toxins) for domestic and exports markets. Recreational fishing is a popular leisure pursuit and the charter sector is a growing domestic and international tourist industry, with both activities widely dispersed within the coastal zone, which also provides value added service opportunities for small coastal towns.

Spatial planning and MPAs

Two commitments under WSSD 2002 included the establishment by 2012 of a representative network of marine protected areas; and integrated marine and coastal area planning and management. The establishment of representative systems and networks of

MPAs is regarded internationally and nationally as one of the most effective mechanisms for protecting biodiversity and a tool for resource sustainability. In Australia the National Representative System of Marine Protected Areas (NRSMPA) forms part of an integrated strategy for marine conservation and management. As identified in the State of the Environment Reports (as outlined in Section 6.5.1 above) and outlined above, environmental management is fragmented across institutions and between the different levels of government, and is not able integrate across a range of scales. There is a lack of a coherent approach to the implementation of the NRSMPA policy as the Commonwealth Government and the state governments exercise separate jurisdictions over the marine environment, with governments declaring MPAs under their respective legislation. The revised Oceans Policy process under the EPBC Act also includes the identification and establishment of marine protected areas in Commonwealth managed waters, but excludes the waters managed by the states and territories. These issues have consequences for Australia in meeting its international requirements and the effective implementation of national MPA policy and other spatial policy initiatives.

Although Australia has achieved considerable progress in MPA declarations, and is recognised as a world leader in MPA development, there is no overarching framework. Progress is not uniform in state managed waters where pressures are the greatest; or across bioregions within the EEZ (Wescott, 2006). A variety of terms have been used in Australia to define protected areas such as MPAs, marine parks, marine reserves, fish sanctuaries and fish habitat areas. Each of these have different purposes and levels of protection and different management regimes depending upon the legislation used to declare them. MPAs are distinguished from fisheries reserves, which are declared primarily for fisheries management purposes under fisheries legislation. While the theoretical benefits from MPAs have been described in many studies, few studies have been undertaken to evaluate these benefits in practice, or to investigate the interactions between the design of MPAs and existing fisheries spatial management systems. In Australia there are conflicting management concepts between the increased use of fishing rights that give fishers security of access to fish resources, and the potential reduction of these rights through loss of access to fishing grounds following MPA declaration. MPAs are promoted as a precautionary tool to protect both fisheries resources and biodiversity, but in Australia there has been little research on identifying threats and assessing the risks to the areas where they are implemented (Baelde, 2005).

Fisheries

The EPBC Act requires all Commonwealth managed fisheries to undergo strategic environmental impact assessments before new management arrangements are brought into affect, and for all fisheries (Commonwealth and state) with an export component to undergo strategic assessment to determine the extent to which management arrangements will ensure that the fishery is managed in an ecologically sustainable way. A review of the first round of strategic assessments under the EBPC Act 1999 highlighted the diversity of fishery types and the different management regimes under which they operate, as well as the differences between fisheries in terms of the various stages of development towards implementation of ESD and an ecosystem-based management regime. Fishery agency submissions varied greatly in approaches by jurisdictions in addressing the EPBC guidelines (Webb and Smith, 2008; Barry, 2006; Marine and Coastal Community Network, 2006). NSESD requires the consideration of the environmental, economic and social, however under the EPBC Act as it relates to the strategic assessment of export fisheries, currently very little consideration is given to the social and economic dimensions. If recommendations from strategic assessments do not include socio-economic factors, it is unlikely that measures will be successful (Webb and Smith, 2008).

Under the EPBC Act a number of environmental provisions have implications for fisheries management. The EPBC protects Australia’s native species and ecological communities by providing for the identification and listing of threatened species and communities, the development of recovery plans and, where appropriate, threat abatement plans. All cetaceans are protected in Australian waters. The EPBC Act also promotes the conservation of biodiversity by providing protection for migratory and other marine species (marine birds, mammals and reptiles). The strategic fishery assessments are conducted against the guidelines for the ecologically sustainable management of fisheries. The principles and objectives of the guidelines are to manage the fishery is a manner that does not lead to over-fishing of the stocks, and for those stocks which are over-fished promote recovery to ecologically viable stock levels within nominated time frames. Fishing operations should be managed to minimise the impact on ecosystems including threatened species and communities and migratory species and the bycatch of other marine species. There is also increasing pressure from conservation non-government organisations (NGOs) regarding conservation of non-protected species and ecosystems.

The state of the environment reporting

Another WSSD 2002 action was the establishment by 2004 of a regular process under the United Nations for global reporting on, and assessment of, the state of the marine environment, including the socio-economic aspects. In Australia DEWHA's State of the Environment team rely on data collection from other state and Commonwealth groups and agencies for compiling the State of the Environment reports, every five years (co-ordination is often difficult as the required information is produced at different times, in different formats and at different spatial scales). At the national level State of the Environment reporting in its current form is solely an information tool rather than a framework for management. As there is no statutory requirement for the Australian Government to adopt any of the management recommendations, although some state and territory governments are required to consider SoE recommendations in their decision-making processes (Chesson and Whitworth, March 2004 p. 83). An issue identified in all the SoE reports was in regard to indicators. For example the 2006 report was based on only 263 indicators from the original 500 core environmental indicators identified in *Core environmental indicators for reporting on the State of the Environment* (Australian and New Zealand Environment and Conservation Council, 2000) due to lack of useful and measurable information. For example the coasts and oceans theme was more than 50% data deficient (Beeton et al., 2006 p.4).

6.8 Summary

In this Chapter the systems model (as developed in Chapters 3 and 4) was applied to examine Australia's position internationally and regionally, its response to international obligations and regional agreements, and how these are being met. Nationally the development and adoption of ESD and EBFM as a policy framework, and whole of government approach to natural resource management, was reviewed, as were the governance and management arrangements under ESD and EBFM principles, and the response to current and emerging oceans and fisheries issues. Aspects of the multi-level and multi-institutional and stakeholder governance and management arrangements were discussed.

Australia is responsible for meeting its international obligations and responding to multiple and interconnected national issues through the development of effective governance policies and management arrangements in an integrated manner. This Chapter outlined Australia's oceans and fisheries governance and management policy framework in response to meeting its international obligations and identified national issues. The adoption of ESD and EBFM principles in Australia is articulated in three key policies. Under NSESD fisheries management agencies are required to adopt a fisheries ecosystem management framework that will provide a more holistic approach to management of oceans and fisheries resources, and includes the environmental, economic and social considerations. Oceans Policy (1998) aimed to provide a national integrated and ecosystems based oceans and planning framework for managing marine sectors including fisheries, and cumulative impacts through marine bioregional plans, based on large marine areas. The EBPC Act (1999) aims to provide an effective framework for environmental protection and conservation of Australian biodiversity, and to ensure fisheries are managed on a sustainable basis.

The adoption of ESD and EBFM has required Australia's existing institutions to change and expand their roles and responsibilities, and develop new approaches. DEWHA and DAFF are the two major institutions responsible for oceans and fisheries policy, and the development of policy initiatives at the Commonwealth level. In Australia oceans and fisheries to are be managed under ESD and EBFM principles as a whole of governance approach. While governance arrangements are in place, there is less evidence of success in relation to implementing integrated arrangements across sectors and jurisdictions, and achievement of inclusive and comprehensive implementation of provisions by management. In Australia, because of the different levels of government, and the different institutions responsible for oceans and fishery governance, this has often led to issues of interplay and fit. The main issues of interplay and fit for oceans and fisheries governance and management appear to be twofold. First, managing jurisdictional roles and responsibilities at the national, sub-regional and state levels; and second, the different approaches in implementing national initiatives and policies within the different jurisdictions and across institutions.

An important challenge is identifying how these are to be rectified in terms of the effectiveness or not of policies and policy initiatives in response to the issues and in meeting the stated objectives. The size and diversity of Australia’s maritime estate, and the complexity of human interactions, together with the different jurisdictional governance and management arrangements provide key challenges. The reviews outlined in this Chapter highlighted some of these challenges, but also noted, there has not been an overall review and evaluation of the suite of policies and initiatives that have been developed. Such an evaluation would be useful in identifying where, why and how key parameters of interplay and fit shape responses. Notwithstanding these challenges, governance and management arrangements and policy initiatives have been responsive to the international requirements and national issues. The national policy framework and policy initiatives and management arrangements set the parameters for oceans and fisheries management under ESD and EBFM principles. The implications for Australian Commonwealth and state and territory fisheries management is discussed in Chapter 7.

CHAPTER 7: AUSTRALIAN COMMONWEALTH AND STATE AND TERRITORY MANAGED FISHERIES UNDER ESD AND EBFM PRINCIPLES

7.1 Introduction

The key determinants of sustainability are the governance and management arrangements used to manage fisheries. To conserve ecosystems and livelihoods requires more than just preventing over-fishing. Sustainable fisheries need enforceable limits on exploitation, effective systems of participatory decision-making, governance and management arrangements, and incentives to maximise the long-term contribution of fisheries to society. Positioning fisheries in a changing world requires adaptation to ecosystems shifts, fluctuations in trade; and awareness that fisheries and communities are nested within broader economic and social systems (Grafton et al., 2008). Although Australia's fishing industry is small when compared to other nations, the commercial and aquaculture sectors are important for export market earnings and for supplying the domestic markets with a wide range of seafood products. Recreational and Indigenous fisheries are also important sectors both socially and economically.

The systems approach and model is to be applied to investigate the management of Australian Commonwealth and state and territory fisheries under Ecologically Sustainable Development (ESD) and Ecosystem Based Fisheries Management (EBFM) principles. A profile of Australian fisheries and their environmental, economic and social context is to be compiled. The governance arrangements as discussed in Chapter 6 set the parameters for Commonwealth and state managed fisheries. How these requirements are incorporated into strategic and operational management by fisheries agencies in Australia will be examined and reviewed. The purpose of this Chapter is to briefly outline Australia's fisheries sectors; resources and habitats; fishing fleets and technology; and the post harvest sectors. As outlined in Chapter 3 the environmental, economic and social dimensions set the parameters for governance and management, and these dimensions as they relate to Australian fisheries management will be discussed.

In Australia ESD and EBFM have been adopted across all jurisdictions as an approach to managing fisheries. The challenge for management within an ESD framework is the sustainable use of fisheries resources; maintaining an economically viable fishing industry; and consideration of the social aspects which impact fishers and their communities. The management of fisheries under EBFM principles requires demonstration that commercial fisheries are being managed on a sustainable basis; this includes both the target and non-target species and the wider environmental considerations. Two reviews of the strategic and operational management in Australia under ESD and EBFM principles have been undertaken. A presentation of certain aspects of the results from the 1998 (Sainsbury, Smith and Webb, 1998) and 2008 (Webb and Smith, 2008) review of Australian fisheries will be presented. This enables analysis of the significant changes, (between 1998 and 2008), in managing Australian fisheries.

7.2 Australian fisheries

In Australia fisheries resources are described in units called a fishery, which are defined by the species caught, the gear and/or fishing methods used, the area of operation and by jurisdictional management (Commonwealth or state) (Williams and Stewart, 1993 p. 3). Australian fisheries are diverse in terms of the resources targeted and the fishing methods used. There are five fishery sectors: commercial, aquaculture, recreational, charter and indigenous. These sectors operate a range of fishing fleet types, with most using increasingly more sophisticated technology. The post harvest sector (processors, marketing and distribution and retail) produce quality and value added products, for the domestic and export markets.

7.2.1 Fishery resources and habitats

Commercial wild caught fisheries range from single species and single gear fisheries to multi-species and multi-gear fisheries, with a geographical range of inshore to offshore fisheries (McPhee, 2008 pp. 27, 51). In Australia there are three types of marine products that supply both the export and domestic markets. These are edible marine products from commercial wild caught fisheries, edible marine products from aquaculture, and non-edible products from both wild caught fisheries and aquaculture. The fish resources exploited include fish; crustaceans; molluscs; elasmobranchs and echinoderms. Species may be exploited by one fishing sector only, or by multiple sectors; species may also be targeted by more than one gear type; and targeted species may be caught across their different age groups and geographical range (Woods et al., 2008). Depending on latitude and physical form estuaries and coastal embayments contain habitats important to fisheries production, such as mangroves, seagrass, saltmarsh and algal beds. Tropical and temperate reefs are also important ecosystems for fisheries production. Many commercial fisheries species are dependent on these habitats at some stage of their life cycle. These habitats are vulnerable to coastal development.

7.2.2 Fishing fleets and technology

Technological advancements have increased the efficiency of fishing and expanded the marine environments that may be fished. Such advancements relate to the design of fishing vessels and the fishing gear being utilised, as well as the variety of electronic equipment used to locate and target fish. As the various components of fishing vessels and their equipment have improved over time, so has the vessel efficiency, and the ability to catch more fish in a shorter time. Understanding fishing fleets and technology profiles is important for managing fishing capacity and effort creep. The technology is now commercially available to classify the bottom type (e.g. rock, sand, silt) by processing the signal from a depth sounder. This, in conjunction with Geographic Information System (GPS), digital charts and personal computers, allows an operator to build a highly detailed three-dimensional model of the fishing grounds. When further integrated with information on catches, weather, time and tide, such systems can incorporate much of the information and experience an operator gains over time (Bureau of Rural Sciences, 28 March 2007).

These technological advancements have resulted in a significant increase in fishing power. For example, the fishing power of a trawler in 2007 may be considerably higher than that of a trawler from the early 1970s. Box 7.2.2 provides an example of fishing power between different sectors of the Queensland trawl fishery.

Box 7.2.2: Changing fishing power in the Queensland trawl fishery.

O'Neill et al. (2003) undertook a comparison of relative fishing power between different sectors of the Queensland trawl fishery based on the effects of improvements in fishing gear and technology on prawn and scallop catches. For the 11 year fishing period from 1989-1999, the results indicated that fishing power for an average vessel increased at 4% in the scallop sector and 27% in the shallow water eastern king prawn sector. O'Neill and Leigh (2007) using the same methods reviewed the fishing power increases in the Queensland east coast trawl fishery for the period 1989-2004. The fishery is the largest prawn and scallop trawl fishery in Australia in terms of numbers of vessels, with 504 vessels licensed as at 2004, and the fishing fleet has gradually upgraded its technology overtime. The analysis considered many different vessel characteristics thought to affect fishing power.

These included:

- engine power (HP), gear box ratio (reduction), average trawl speed (knots), fuel capacity (litres), fuel consumption per night (litres), propeller size (inches) and presence or absence of a propeller nozzle;
- navigation equipment: presence or absence of global positioning system and plotters, computer mapping software, sonar and colour sounder;
- the use, position, type and size of try-gear; try-gear is a small (1–3 fathom) net used for frequent 10–20 min sampling of trawl grounds;
- the type and use of by-catch reduction devices (BRD) and turtle exclusion devices (TED); and
- trawl net configurations: number of nets (single, double, triple, quad or five nets), total net head rope length (fathoms) combined for all nets, net mesh size (mm), type of ground chain (fixed drop chain, drop chain with sliding rings, drop rope and chain combined, looped chain or other less common configurations), chain size (mm), type of otter board (Bison, flat, Kilfoil, Louvre or other less common types) and size (total board area = board length × width).

For the period 1989-2004 the models estimated overall fishing power increased 6% in the northern tiger prawn, 6% in the northern endeavour prawn, 12% in the southern tiger prawn, 18% in the red spot king prawn, 46% in the eastern king prawn, and 15% in the saucer scallop sector. The results illustrate the importance of ongoing monitoring of vessel and fleet characteristics and the need to use this information to standardise catch rate indices used in stock assessment and management. However, fishing power analyses can be affected by confounding factors, which make it difficult to determine whether a change in catch rate is due to variation in population abundance, or changing fishing power (O'Neill and Leigh, 2007).

O'Neill et al. (2003)*;* O'Neill and Leigh (2007)

7.2.3 Post harvest

The post harvest sector includes seafood processing (value added), distribution, wholesaling and retailing. Seafood safety, quality and consumer preferences (products) are important factors for both export and domestic fisheries markets. In Australia for 2008 the key edible export species (from highest to lowest by value) were rock lobsters, abalone, tuna and prawns. The major export destinations and species were Hong Kong (rock lobster and abalone), Japan (tuna, rock lobster, abalone, and prawns), the United States (rock lobster) and Chinese Taipei (rock lobster). The key non-edible products were pearls with key destinations Hong Kong, Japan and the United States. Australia also imports edible fisheries products from the following key sources Thailand, New Zealand, Viet Nam and China, the key products comprise canned fish, frozen fish fillets; prawns (fresh, chilled, frozen), and canned crustaceans and molluscs (Pham and Peat, 2009 pp. 19-24). Australian seafood is also important in providing quality products to the domestic market and the nutritional benefits are promoted as important to a healthy diet. Australia has a diverse range of freshwater and marine habitats that support aquatic species, with more than 800 seafood species commercially harvested and sold in Australia, under about 300 marketing names, for local and overseas consumption. Fisheries Research and Development Corporation (FRDC) in partnership with Commonwealth Science and Industrial Research Organisation (CSIRO) and Seafood Services Australia developed the Fish Names Standard and the Fishnames Database. Three important publications were the *Australian Seafood Handbook* (Yearsley et al.,1999); the *Australian Seafood users manual* (Yearsley et al., 2000); and the *Guide to imported seafood species* (Yearsley et al., 2003).

The need for Standard Fish Names in Australia was recognised as early as the 1920s in order to address growing confusion in the market caused by local and regional variations in the names being used; some species being known by more than one name; and the same name being used for more than one species. The Australian Fish Names Standard AS SSA 5300 addresses these issues by assigning one Standard Fish Name for each species. It includes Standard Fish Names to be used in Australia for commercial and recreational species of fish and invertebrates; other finfish found in Australian waters; and seafood species imported into Australia. Industry-wide adoption of Standard Fish Names is vital for: accuracy of trade descriptors and labelling; public and consumer confidence; efficiency in seafood marketing; effective fisheries monitoring and management; sustainability of fisheries resources; effective traceability and food safety management; and industry viability and profitability. The Australian Fish Names Standard AS SSA 5300 was approved by Standards Australia as an official Australian Standard in 2007. The online Standard Fish Names Database includes all species listed in the Standard. The Standard specifies that fish sold to consumers (e.g. retail sales and restaurants) must be identified by their standard fish name; and fish sold other than directly to consumers (e.g. wholesale, export, import) must be identified by their standard fish name or scientific name (Seafood Services, 2010a).

The Seafood Experience Australia (SEA) was launched in December 2005, with the aim of becoming the first industry owned corporation formed to promote Australian seafood to consumers both in Australia and overseas. SEA builds awareness of Australian seafood in key markets, and develops market opportunities (Seafood Experience Australia, 2010). Seafood Services Australia (SSA) was established in 2001 by the Fisheries Research and Development Corporation and the Australian seafood industry. SSA encourages and supports people, businesses and organisations in the seafood industry who want to improve and add value to their business; capitalise on opportunities to develop the seafood industry; improve their environmental performance; meet consumer expectations; and receive broad community support for their activities (Seafood Services Australia, February 2010b).

7.3 Australian fisheries: the environmental, economic and social context

As outlined by The Allen Consulting Group (2004) Australia's marine industries (marine tourism, oil and gas, fisheries and seafood, shipping, shipbuilding, and port based industries) make an important contribution to the economy and society, directly through the production of goods and services and employment; and indirectly by value added and flow on production and employment in other sectors of the economy. For the period 1995-2003 the largest industries were marine tourism and offshore oil and gas. The fisheries and seafood industries comprise marine fishing, aquaculture and seafood processing. While the economic contribution was small it is the most labour intensive of all marine industries (9.1% of total employment in marine industries); and the fisheries and seafood industry was the third larges exporting marine industry (after marine tourism and offshore oil and gas) (The Allen Consulting Group, 2004 pp. iv, 29-31). Understanding the environmental, economic and social context for Australian fisheries is important for developing effective management and responses to issues. Some of these aspects as they relate to Australian fisheries are outlined below.

7.3.1 Environmental dimensions

Fishing occurs throughout the Australian fishing zone and across a diverse range of habitats. In comparison to other fisheries in the world, Australia's fisheries resources are not as abundant due to low nutrient waters, a narrow continental shelf, the predominate southward flow of the main Australian coastal currents, and the lack of permanent upwellings (Williams and Stewart,1993, pp. 1-2). Although Australia's fishing industry is small compared with other nations, ranked 52nd, the commercial fishing and aquaculture sectors are important nationally, for export market earnings and for supplying the domestic markets with a wide range of seafood products. The total value of production from commercial wild fisheries and aquaculture products are ranked fifth in value after the rural industries of beef, wool, wheat and dairy. Aquaculture is now one of Australia's fastest growing rural industries (Mcphee, 2008; Department of Foreign Affairs and Trade, August 2008).

Australia's commercial fisheries exploit over 300 species and operate in all areas of inshore and offshore waters. Recreational fishers exploit fish and invertebrates that are taken mostly from nearshore waters near population centres, but increasingly also taken in remote areas of the mainland and the offshore islands. While land-based aquaculture is increasing most of Australia's production is sourced from in water aquaculture activities (Ward and Butler, 2006 pp. 15-24). Although states and territories assess the status of their fish stocks, these assessment processes are different to those used for Commonwealth managed fisheries, and therefore a meaningful nationwide fish stock assessment is difficult.

The Australian Bureau of Agricultural and Resource Economics provide annual fisheries statistics reports, which provide profiles of Australian wild caught and aquaculture fisheries by jurisdiction; main fishing area; key target species; fishing methods; and number of vessels and permits. The reports also provide information for each jurisdiction on wild catch and aquaculture fisheries production by weight and value. In 2007-08 production of the key wild caught target and aquaculture species by jurisdiction were:

- Commonwealth: prawns, tunas and sharks;
- New South Wales (NWS): oysters (aquaculture), prawns, sea mullet and rock lobster;
- Victoria (VIC) abalone, rock lobster and trout (aquaculture);
- Queensland (QLD): prawns (wild caught and aquaculture), coral trout, crabs and barramundi (aquaculture);

- Western Australia (WA): rock lobster, pearls (aquaculture), prawns, scallop and abalone;
- South Australia (SA): southern bluefin tuna (aquaculture), rock lobster, prawns, abalone, and oysters (aquaculture);
- Tasmania (TAS): salmonids (aquaculture), abalone (wild caught and aquaculture) and rock lobster; and
- Northern Territory (NT): gold band snapper, crabs, barramundi and mackerel (Pham and Peat, 2009 pp.9-12).

Production by sector for the key wild catch species were prawns, rock lobster, tuna and abalone and; and for aquaculture species prawns, oyster, tuna and salmonids. The volume of Australian fisheries production over the last decade has remained relatively stable for key species such as rock lobster and abalone. In 2007/08 the total volume of production was 236,000 tonnes approximately the same level as in 1998/99. In recent years sardines (pilchards) have emerged as a major production species as feed for tuna ranching, bait for recreational fishers and for pet food. In 2007/08 sardines accounted for the highest individual catch by volume (14%) followed by salmonids (11%); prawns (10%); tuna (6%); and rock lobster (6%) (Pham and Peat, 2009 pp. 15-16).

Climate change is an emerging issue for fisheries. There are many direct and indirect ways in which climate change forces may affect biological processes at a range of spatial and temporal scales. These are likely to have a large impact on living marine resources and in turn on the economic and social aspects of fisheries. The variables that are expected to drive climate change impacts on fisheries and aquaculture are temperature, ocean currents, winds, nutrient supply, rainfall, ocean chemistry including acidification, and extreme weather conditions. The main risks for capture fisheries include changes to habitat, nutrient supply; productivity, migration of species, health of ecosystems and stocks; population sizes and abundance; and shifts in geographical distribution of species. The main risks for aquaculture include species growth; disease resistance; nutrition issues; water quality; industry development and suitable site selection; destruction of cages from extreme weather events; and effects of climate change on food sources. Effects will be mixed and uncertain, according to the physical changes in the regional environment but are likely to impact on the biological, economic and social components of many fisheries, and pose significant risks to the sustainability of fisheries and aquaculture sectors. Currently Australian fisheries and aquaculture management policies do not incorporate the effects of climate variability or climate change in setting harvest levels, or when developing future strategies. Baseline information on the coupled biological and socio-economic components will be needed to assess climate impacts. To effectively assess the impact of climate change on fisheries will require a wide range of data types (Hobday et al., 2008 pp. vi-16).

7.3.2 Economic dimensions

The gross value of production in 2007/08 for commercial wild caught fish and aquaculture was $2.19 billion with Commonwealth fisheries accounting for 13% and state and territory for 87% (TAS 22%; SA 21%; WA 20%; QLD 12%; NSW 6%; VIC 4%; NT 2%). For the period 2007/08 the top five (highest to lowest) by value of production were rock lobster ($407 million), salmonids ($299 million), prawns ($268 million) tuna ($210 million) and abalone ($189 million). Since 1998/99, however the gross value of Australian fisheries production has fallen by 22%. The reasons for this decline have been due to the decline in value of key species as a result of falling unit prices (Pham and Peat, 2009 pp.1-8).

For the period 2007/08 the total export value was $1.3 billion, with approximately 80% of export value derived from edible fishery products such as fish and shellfish, with the remainder comprising non-edible products such as pearls and fish meal. The top five exports by value (highest to lowest) were rock lobster ($401 million), pearls ($264 million), abalone ($217 million), tuna ($202 million), and prawns ($69 million); and the top five export destinations (highest to lowest) were Hong Kong, China, Japan, United States, Chinese Taipei and Singapore. Since 2000/01 the real value of Australian exports has fallen by 49%. Australian fisheries are subject to a wide range of changing macro and micro drivers. In recent years the strong appreciation of the Australian dollar has made exports less competitive, and imports more attractive to domestic consumers, and this trend continued in 2007/08 (Pham and Peat, 2009 pp.4,17). The recent micro drivers that have affected Australia’s fishers nationally are variable costs of production such as diesel fuel and labour costs.

Historically Australia has been a net importer of fisheries products in volume terms, but a net exporter in dollar terms. In recent years the gap between the value of Australian fisheries exports and imports has closed. In 2007/08 Australia became a net importer of fisheries products in value terms at $1.4 billion. The top five imports by value (highest to lowest) were canned fish ($257 million), frozen fish fillets ($228 million), fresh, chilled or frozen prawns ($167 million), pearls ($166 million), and canned crustaceans and molluscs ($128 million); and the top five import sources (highest to lowest) were Thailand , New Zealand , Viet Nam, China, and Malaysia (Pham and Peat, 2009, pp.17-18).

7.3.3 Social dimensions

The commercial wild caught and aquaculture sectors provide income and employment, with many local communities dependent upon these sectors for their livelihood and wellbeing. The Australian Bureau of Statistics (ABS) reports on fishing employment from the Labour Force Survey (as part of the monthly population survey) which indicated that in 2007/08 employment from commercial fishing was 13,000 people, more than 30% higher than in 2006/07, but around 32% lower than in 200/01. Information is also collected in the ABS census (collected every five years) which provides further information on total employment in the fishing industry. For 2006 of the 9,736 people employed in the industry more than one third (3,628 people) were employed in aquaculture, with wholesaling employing 4,202 and seafood processing employing 2,001 people; and total employment by jurisdiction was QLD (2,011); NSW (1,815); SA (1,769); Tas (1,578); WA (1,477); Vic (794); NT (284); and Act (7). FRDC stated that data collected by ABS is not disaggregated in sufficient terms, and there is an overlap with other categories such as transport and generalised seafood processing (Pham and Peat, 2009 pp.27-28).

Recreational fishing ranks high, as one of Australia’s most popular outdoor leisure activities. The recreational fishing sector is widely dispersed and the large number of participants is increasingly leading to substantial catches. Recreational fisheries have flow-on benefits for small business and local communities and recreational fishing infrastructure also attracts tourism to many areas. Australia recognises the importance of the cultural interests and rights of indigenous peoples. These include the observation of cultural duties, lifestyle choices and the importance of seafood as an important component of a traditional diet, particularly for coastal dwelling communities (Williams and Stewart, 1993 pp. 10-11; Hanna and Jentoft, 1996; Henry and Lyle, 2003). Australia's fishery sectors have a high social value, and the sustainability and maintenance of fishing communities are considered a valuable social asset in their own right.

Although the social dimension is considered important, the analytical and theoretical underpinnings are not well developed or articulated in Australia. Assessing social impacts can help in choosing between management options that have similar resource and economic outcomes, but may have a range of different social impacts. It can also assist in developing appropriate policies for assisting necessary social transitions associated with any changes implemented in the fishing industry (Lehtonen, 2004; Schirmer, 2005). The management of all fishing sectors activities has implications for fishers and fishing communities. The Fisheries and Research and Development Corporation (FRDC) has initiated a Social Sciences Research Co-ordination Program to address the limited understanding of the social aspects of the fishing and aquaculture industry (including fisheries management; change management; community perceptions; research and development adoption; and industry and communities' ability to adapt). The program's focus is on the individual, business, group and sectoral levels, and the ways in which fishing in these sectors interacts with the broader community and sub-regional industries. According to FRDC the current minimal and unco-ordinated information in this area inhibits effective management of social issues affecting fishers and the fishing industry; the facilitation and development of leadership; and communication and the adaptation capacity within and across the different sectors. The program is designed to address the social science research and development issues, and complement biological and economic research (Brooks, 20 January 2009 pp. 4-5).

7.4 Commonwealth, state and territory managed fisheries: some key considerations

As discussed in Chapter 6 the national policy framework and policy initiatives and legislative requirements set the parameters for fisheries management. The fisheries management agencies are responsible for incorporating ESD and EBFM requirements into short and long-term strategic and operational management, and demonstrating that the intent of the governance policy parameters and fisheries management objectives are being met. Commonwealth and state fishers are managed under respective jurisdictional legislation and fisheries management Acts, regulations, and any other national legislation that may relate to fisheries management. The Department of Agriculture, Fisheries and Forest (DAFF) sets the policy for fisheries and has an administrative role in fisheries management. Although the Department of the Environment, Water, Heritage and the Arts (DEWHA) does not directly administer fisheries, it does administers the EPBC Act which has implications for fisheries in regard to strategic assessments for export fisheries and the declarations of Marine Protected Areas (MPAs). The management of fisheries is shared between the Commonwealth and state and territory governments, with the roles and responsibilities delineated under the Offshore Constitutional Settlement (OCS). The Australian Fisheries Management Authority (AFMA) as a statutory commission has responsibility for the management of Commonwealth commercial fisheries. AFMA shares joint responsibility for managing some fisheries with the states and Northern Territory. Western Australia is the only State with a standalone fisheries department, with the other states managing fisheries within respective Departments of Primary Industries (McPhee, 2008). State and Territory Department of Primary Industries; and the W.A. Department of Fisheries are responsible for all the fishing sectors (commercial, aquaculture, recreational, charter and indigenous). Lists of Commonwealth, state and territory managed fisheries and aquaculture, together with details of management arrangements can be found at the respective web sites. Some important aspects of Australian fisheries management are discussed under the following headings: consultation and participatory decision-making; management arrangements; management processes and measures; management and fishery assessments; data, information; and research.

7.4.1 Consultation and participatory decision-making

Consultation and participatory decision-making is an important feature of ESD and EBFM in Australia, and is important in developing fishery management arrangements. Australian Commonwealth and state governments and fisheries management agencies use a range of consultative and collaborative participatory mechanisms. Interest in a more delegated co-management model, where feasible, represents another potential change and approach to fishery management arrangements in Australia.

Consultation

Consultation, regarding key fisheries management arrangements with the relevant stakeholders is an important feature of Australian fisheries management agencies. AFMA has a responsibility to consult with all stakeholders on fisheries resources when making management decisions regarding Commonwealth fisheries. This is achieved through the Management Advisory Committees (MACs) established by the Australian Fisheries Management Authority Board for each major Commonwealth managed fishery. MACs provide advice on fishery specific management issues; and advise the AFMA Board on fishery objectives and management arrangements. Resource Assessment Groups (RAGS) provide advice on the status of fish stock, substocks, species (target and non-target) and on the impact of fishing on the marine environment, and where relevant on economic and compliance factors that affect the fishery. RAGS report to both the AFMA Board and the MAC but are not controlled by the MAC (Australian Fisheries Management Authority, 14 August 2006).

State and territory fisheries also use MACs or similar groups such as Fisheries Management Committees (FMCs) or Fisheries Advisory Committee (FAC). Another example is the Western Australian ESD Fisheries Reference Group. The purpose of the group is to ensure the effective development and implementation of ESD policy for WA fisheries and provides advice to the Executive Director of the Department of Fisheries (McPhee, 2008 pp. 110-111). Commercial and recreational fishers are often represented by peak bodies. As McPhee (2008) highlights there are practical challenges for participative forums such as the MACs in terms of how cross fishery, multi-species or regional issues are facilitated. Continuity of membership and continued attendance at meetings is important. For some fishers however, this may have economic consequences as they forgo income from fishing while attending meetings. To effectively participate members my require training, currently there a range of programs which commercial and recreational fishing MAC members may participate in for training and capacity building (McPhee, 2008 pp. 114-116).

Co-management: a delegated model

Two recent studies regarding a more delegated model of co-management have been undertaken. One by the Fisheries Research and Development Corporation National Working Group (2008) which discusses co-management for all fisheries sectors; and the other by Fisheries Economics, Research and Management Pty Ltd, January (2008) reviewing co-management in Commonwealth fisheries.

In 2006 FRDC commissioned a report to aid an understanding of the drivers behind co-management, the potential benefits and the conditions necessary for its successful implementation. The report *Co-management: managing Australia's fisheries through partnerships and delegation* provides a practical "how to guide" and framework which might be applied to the different fisheries sectors, based on four co-management models: centralised, consultative, collaborative or delegated. All fisheries management agencies in Australia have moved from a fully centralised system to the consultative model, and some have moved to the collaborative model, but do not involve any decision-making or service delivery to fisheries. In moving towards a delegated role, it requires discussing what range of fisheries management functions should remain with government and which may be delegated to fishers. Under a delegated model, negotiated management decisions are made by governments, fishers, fisher organisations and other stakeholders within a broad framework, where agreed functions or services can be delivered, by a fisher organisation under a formal agreement, once preconditions for delegation have been met to the satisfaction of all parties (Fisheries Research and Development Corporation National Working Group, 2008 pp. 1-2). Not all the preconditions have to be satisfied before beginning dialogue between government, fishers and other stakeholders, but the more pre-conditions that have not been met the longer the process will take, and the more complex will be the negotiations. A stepwise approach recognises that limited financial and human resources could be a factor for many fisheries, but this should not limit the opportunity to work towards achieving the benefit of co-management (Fisheries Research and Development Corporation National Working Group, 2008 pp. 25-28).

AFMA also funded a research project *Co-management for Commonwealth Fisheries* (Fisheries Economics, Research and Management Pty Ltd, January 2008). The overall objectives of the project were to determine the suitability of more delegated co-management arrangements for AFMA's fisheries, and evaluate the feasibility of introducing a more delegated co-management approach in selected Commonwealth fisheries (Fisheries Economics, Research and Management Pty Ltd, January 2008 p. 4). Two conclusions about the feasibility of a co-management approach were found to be applicable to all Commonwealth managed fisheries. First, there is currently no enabling legislation to allow for co-management in Commonwealth fisheries. Furthermore, there is a legislative overlap and conflict, where Commonwealth fisheries are subject to regulation under the *Fisheries Management Act 1991*, the *Fisheries Administration Act 1991*, the OCS agreements, and the *Environment Protection and Biodiversity (EPBC) Act 1999*. The implementation of co-management would require harmonisation of the EPBC Act and Fisheries Management Acts, as well as the introduction of enabling legislation for co-management agreements to be entered into. Second, because of the current legislative framework, there are two Federal government departments (DAFF and DEWHA) and one Statutory Commission (AFMA) involved in the management of Commonwealth fisheries. This has led to a blurring of responsibility for final decision-making and in some cases conflict between decision-making authorities. According to Fisheries Economics, Research and Management Pty. Ltd., harmonisation of legislation, and clarity of legislative hierarchy could resolve many of these issues. The Great Australian Bight Trawl and the Southern Blue Fin Tuna fisheries were chosen as case studies in this project because these had the potential for a more delegated co-management approach. Given that most other Commonwealth fisheries do not meet most or all of the pre-conditions for co-management, as defined in this project, the current potential for the broad application of a more delegated co-management approach in Commonwealth fisheries is considered to be limited (Fisheries Economics, Research and Management Pty Ltd, January 2008 p. 4-6). Despite these issues certain aspects of the delegated model are being trialled in selected AMFA fisheries, including the SESSF through the port of Lakes Entrance, Victoria and the Great Australian Bight trawl sectors, and will be discussed in Chapter 8.

7.4.2 Management arrangements

According to Hilborn (2007) there are four major categories of fisheries management objectives; biological, economic, social and political. These objectives may be compatible or in conflict. Fishery stakeholders (fishery sectors, government, managers, non-government organisations, and the general public) also have a range of objectives. Until these objectives are clarified it is hard to define what is meant by success in fisheries management, and learning from experience will be limited. One difficulty in implementing EBFM is that trade-offs are inevitable, but there is very little discussion of how these trade-offs are to be made (Sanchirico et al., 2008). Some examples of trade-offs include harvesting fish now versus leaving them in the water to produce surplus for harvesting in the future; economic efficiency versus employment opportunities; or inexpensive fishing practices that can have bycatch and habitat impacts versus selective fishing practices (Walters and Martell, 2004, pp. 20-22).

Fisheries objectives as reflected in traditional management have, and will continue to change under ESD and EBFM principles in Australia, but this transition is not without its challenges. As Olsson et al. (2008) discussed there is an urgent need to identify strategies that have enabled successful transitions from traditional management to ecosystem-based management. The authors used the Great Barrier Reef Marine Park (GBRMP) as a case study to analyse the strategies and actions that enabled the transition toward an EBFM approach in the GBRMP. In 1998 the GBRMPA initiated a major rezoning of the marine park called the Representative Areas Program (RAP). The focus was on protecting biodiversity and maintaining ecosystem function and services rather than on maximising the yield of commercially important fisheries. A common feature of the GBRMP strategy was anticipating and addressing potential difficulties to the implementation of an EBFM approach. Communication and information played an important role throughout the process. The GBRMP case illustrated that policy development and implementation are complex and highly dynamic. The authors suggest that additional empirical studies, case study analyses, and comparative studies, can help to develop a better understanding of strategies for transformation in governance towards EBFM, under various social and ecological conditions, and in the face of uncertainty and rapid change.

Structural adjustments and compensation

Structural adjustment can be applied with the objective of removing excess capacity from the fishery; promoting economic efficiency; and mitigating the impacts of changed access arrangements, as for example with the introduction of MPAs. In Australia government financial support in the form of compensation has been provided for affected parties. However, with the exception of Western Australia there are no legislative requirements for compensation, and its application is based on moral and political grounds. There are a number of practical challenges in applying structural adjustments and compensation. These include ensuring fishing effort removed from the fishery does not re-enter the fishery by activation of effort that was previously latent in the fishery; providing sufficient financial resources to remove enough fishing effort to make a difference; and ensuring effort creep in remaining vessels does not compromise the reduction in capacity. Anticipation of future buybacks can encourage extra capacity buildup before the buy-back process begins. Compensation can include business restructuring assistance (for those wishing to remain in the fishery); business exit assistance such as licence buy-backs (often based on a competitive tender process); employee assistance (one off payments to assist employees who lose their jobs to cover short-term dislocation costs); social and community assistance (targeting regional communities impacted by the industry restructure in developing new investment opportunities and employment); and business advice (for associated onshore businesses) (McPhee, 2008 pp. 201-207).

A recent example is the structural adjustment for Commonwealth fisheries as part of the $220 million *Securing our Fishing Future* package announced in November 2005. It was designed to deliver profitable and sustainable Commonwealth fisheries for the future, through a buyback of up to half of the then existing Commonwealth fishing concessions. The primary fisheries targeted were the Southern and Eastern Scalefish and Shark Fishery (SESSF), the Eastern Tuna and Billfish Fishery (ETBF), the Bass Strait Central Zone Scallop Fishery (BSCZF), and the Northern Prawn Fishery (NPF). It was the largest structural adjustment package ever offered to the Australian fishing industry. The package comprised of A$150 million for a one off, capped fishing concession buyout; a A$70 million complementary assistance to minimise impacts on onshore business linked to the fishing industry; and offset costs for skippers and crew who lost their jobs. As part of the *Securing our Fishing Future* package, the South-east Network of Commonwealth Marine Reserves (CMRs) was declared. It was intended that the structural adjustment package would also address the displaced fishing effort arising from the new protected areas (Department of Agriculture, Fisheries and Forestry, 26 October 2009; Australian Fisheries Management Authority, 23 November 2005; Department of the Environment, Water, Heritage and the Arts, 9 December 2009).

Minnegal and Dwyer (2008) assessed that approximately 34% of the 1600 fishing concession were removed in the buy back of which 95% were from the four targeted fisheries. The data does not however, reveal, either numbers of owners of fishing concessions who relinquished Commonwealth fishing concessions, but retained others, or retained the right to fish in state waters. With the exception of the BSCZF and NPF fisheries, the proportion of concession holders in a particular fishery who relinquished all rights in Commonwealth waters was less than the proportion of concessions removed from the fishery. These differences can be partially explained by fishers in the NPF being specialists, while the others are generalists with interests in more than one fishery. In some cases concession holders with more than one concession in a particular fishery received large payments for an active concession but continued operating using what had previously been an inactive concession in the same fishery. One aim of the buyback was to improve both the sustainability and the profitability of the fishing industry, but the economic position of a fisherman is not the only measure of sustainability of the industry; the social aspects are equally important and outcomes may impact the social dynamics of local communities.

The BSCZF was also targeted but the fishery was closed from 2006 until mid 2009. An analysis of the effects of the fishery buyback for the other three targeted fisheries, the NPF, ETBF and SESSF fisheries was undertaken by ABARE. The analysis considers the immediate effects of removing fishing capacity from a fishery (as assessing the longer term effects requires a longer time series of data). The indicators used in the analysis were net economic returns, output to input ratios, and indices of catch per unit effort and costs per unit of catch. In each of the fisheries the net economic returns have improved in the post buy-back period. The observed improvements in net economic returns, are relatively small ($39 million) however, when compared with the $149 million spent in the buyback. It is therefore important that the fisheries are managed to ensure the long-term benefits of the buyback are realised Vierira et al. (2010 pp. 1-5).

Monitoring, compliance and enforcement

There is a high level of community expectation that fishery resources will be maintained at sustainable levels; the aquatic habitat will be protected; and that incentives for illegal activity will be minimised. The *Australian fisheries national compliance strategy 2005-*

2010 (National Fisheries Compliance Committee, 2005) outlines the strategic objectives that Australian fisheries agencies are to pursue in implementing monitoring, compliance and enforcement strategies, while acknowledging the differences in legislation, policy and management arrangements which apply across Commonwealth, state and territory fisheries. Optimal levels of compliance with fisheries laws are to be achieved by maximising voluntary compliance (targeted education, advisory and extension programs) and creating an effective deterrent against illegal activities (integrating compliance strategies into fishery management arrangements, compliance planning, legislative deterrents, enforcement) and monitoring and reporting on effectiveness.

Fisheries dependent monitoring of commercial fisheries activity includes catch and effort via a compulsory program of catch returns generally in the form of compulsory logbooks recorded daily, and submitted to the management agency weekly or monthly. Although logbooks vary, the basic information required includes level of effort (e.g. days fished); the area(s) fished; and the composition and volume of retained catch. Logbook information is used for stock assessments and the calculation of gross value of production (GVP) of the fishery; and increasingly for estimating compensation afforded to a fishery business, as a result of changing access arrangements. Logbooks have limitations as they may be subject to deliberate misreporting; species identification in multi-species fisheries can be difficult where different species are recorded under one common or marketing name. The spatial scale recorded is generally coarse (6x6 nautical miles) and does not match the scale at which management decisions are made (although the use of global positioning system (GPS) and recording of longitude and latitudes into quota fisheries will provide more fine scale spatial data). Logbooks only record retained species and do not include bycatch, although generally it is mandatory to record interactions with protected species. To over-come these limitations observer programs are often implemented which may be voluntary (collecting information for research purposes) or compulsory (validation of catch and effort data, discard estimation, bycatch monitoring, and compliance with regulations) (McPhee, 2008 pp. 80-83).

Technical advancements provide different monitoring options such as vessel monitoring systems (VMS) and (GPS) tracking units, which are used to track the location of a vessel. This serves as an effective method of enforcing spatial and temporal closures; determines when a vessel has left port and is fishing, an integral component of an effort management regime, based on the number of days/nights fished. VMS can also be useful for evaluating the spatial scale of fishing activity, which is important for understanding the spatial and temporal scale of fishing impacts and their intensity. There is also interest in using onboard fixed cameras to monitor bycatch and interactions with threatened and protected species, which may prove to be more cost effective than using human observers. There can be a significant bias in estimating the size of the stock or assessing other biological parameters in fisheries dependent monitoring. To counter this independent surveying of fisheries are undertaken based on appropriate experimental designs and standardised methodologies, and independent of market forces. Acoustic surveys are used to locate schools of fish and provide an estimate of overall stock size. Given the cost, independent monitoring is generally undertaken only for the large and higher value fisheries. Techniques for monitoring recreational and Indigenous fishing involves the surveying of fishers using a variety of survey techniques including on site (boat ramps or shore based sites) interviews called creel surveys; offsite techniques include phone surveys and diary surveys; and fishing records from competitions and game fishing tournaments (McPhee, 2008 pp. 83-88).

7.4.3 Management processes and measures

Fisheries allocation between sectors

The allocation of, and access to, fisheries resources is a challenge for fisheries governance and management. There is the issue of allocation between fishery sectors, for example between recreational and commercial fishing, and between commercial fishing sectors. Resource sharing arrangements formalise allocation arrangements for all relevant user groups. In 2003 as part of *Looking to the future a review of Commonwealth fisheries policy* stakeholders identified a need for the Australian Government to formally address the issue of resource sharing between users. Five sectors (commercial, recreational, charter, aquaculture and Indigenous fishing sectors) require access to fishery resources, regardless of whether the Commonwealth or state or territory governments manage the resources. This has increasingly led to disputes between the sectors about who has the most right to access certain fish stocks. Clear arrangements exist to limit commercial catches, and recreational and charter catches may also be limited by various means (but less so currently), as is aquaculture access to marine areas and broodstock. However, there is no overarching framework that provides a transparent mechanism to support decision-making on how much each fishery sector should be allocated for a given fish stock (Department of Agriculture, Fisheries and Forestry, 2003 pp. 26-29).

The concept of allocation is one of increasing national and international interest to those involved in fisheries management. The “Sharing the Fish” conference 2006 held in Perth, Western Australia, focused on a broad spectrum of allocation issues organised under three broad topics: allocation across jurisdictions (international, regional and bilateral resource sharing); national allocation across sectors (between different fishery sectors, including spatial and temporal fishery aspects); and allocation within sectors (across types of fisheries i.e. trawl, line, traps, hand collection; and allocation methods i.e. individual transferable quotas, quotas, total allowable catch) (Sharing the Fish Conference, 2010).

Recreational fishing can result in significant harvesting of marine species, and in some cases the catches from recreational fishing may need to be incorporated into stock assessments and in management measures, when considering harvest strategies for a particular species. While the impacts of a single angler may be considered less than that of a commercial fisher, it is the cumulative impact from a large number of recreational fishers that may result in significant impacts from recreational fishing in terms of catch of targeted species, bycatch issues, and damage to critical habitats. Australia recognises the importance of the cultural interests and rights of Indigenous peoples (Williams and Stewart, 1993 p. 11). The National Recreational and Indigenous Fishing Survey of Australia commenced in May 2000, it was conducted for twelve months through a screening survey and diary of intending fishers. The survey was the first attempt to obtain detailed information on nation-wide catch and fishing effort of Australian recreational and Indigenous fishers. The aim of the survey was to obtain reliable, consistent and comparable data Australia-wide on angler participation and demographics; catch and effort; attitudes and awareness; and economic activity. It also obtained information on indigenous fishing in Australia to help achieve a wider understanding of a range of issues including the importance fishing plays in many indigenous communities. The survey also wanted to obtain information on international tourist fishing activities (Henry and Lyle, 2003 p. 12).

As McPhee (2008) explains interest in recreational fishing has grown and frequently recreational anglers support the creation of recreational only fishing areas where commercial fishing is prohibited and where it is agreed that environmental, economic and social benefits accruing from recreational fishing outweigh commercial fishing. In Australia the declaration of recreational fishing areas and species, however has been often ad hoc; can occur outside the standard fisheries management consultative framework; and may not be based on the rigorous application of all the relevant information. Economic factors are often cited as the reason for reallocation but claims need to be investigated and assessed for both commercial and recreational fishing. There is limited social information which makes it difficult for managers to consider social issues. While there is information regarding the negative social impacts on commercial fishers from reallocation of resource access, information regarding the social benefits accruing to the recreational fishing sector from reallocations are generally lacking (McPhee, 2008 pp. 155-167). Understanding the impact of different drivers (which can be environmental, social or economic) for reallocating resources between sectors, will be important when considering the management options and arrangements, and monitoring or assessing the effectiveness of reallocations. Some of these fishery sector allocation issues can be illustrated in the case of the ban on commercial fishing in the estuarine waters of New South Wales as outlined in box 7.4.3.1 below.

Box 7.4.3.1: An example of resource allocation between commercial and recreational fishers in New South Wales.

In its effort to resolve the conflict between commercial and recreational fishers the New South Wales Government in 2001 declared that commercial fishing would be excluded from 29 NSW estuaries and convert these to Recreational Fishing Havens. In May 2001 Lake Macquarie was the first estuary where commercial fishing ceased. Lake Macquarie is one of the largest saltwater coastal lakes in the southern hemisphere. It faced increasing environmental problems from an expanding urban population; coastal development and eutrophication from run off; poor water quality; introduced species; and commercial and recreational fishing. Lake Macquarie had been fished commercially for over 100 years using small motorised boats alone or in pairs using hauling nets. The majority of the catch went to the Sydney fish markets valued at A$1 million annually, with only a limited amount sold locally. Two co-operative retail seafood businesses, owned and operated by the commercial fishers, supplied fish to local customers valued A$100,000 per annum each. In the last two decades as a result of the increase in urban population and tourist visitors approximately 200,000 people fished recreationally on the lake annually and spent an estimated A$12 and A$24 million a year on fishing related activities. The conflict between commercial and recreational fishers was a result of targeting the same fish stock (yellowfin bream, dusky flathead, tailor, luderick, trumpeter whiting and leather jackets) in the same spatial areas. Recreational fishers were mainly concerned with possible impacts of haul nets used by commercial fishers on the seagrass habitats (a recent study conducted by NSW Fisheries, however revealed minimal impact of netting in the lake) of the lake, and the perceived decline of size and numbers of fish species.

The ban on commercial fishing in Lake Macquarie had significant social and economic impacts on the commercial fishers. Despite efforts by NSW Department of Primary Industries to consult with commercial fishers, confusion and disagreements remained over a number of key issues. In particular the reason for the decision and its intended outcomes; about community consultation processes; and compensation and how compensation would ensure a secured future for commercial fishers. Despite the lack of evidence of impacts from commercial fishing on recreational catches, the phasing out of commercial fishing was frequently presented as a solution to the perceived conflict. Commercial fishers had agreed to a number of spatial and temporal restrictions on their activities, and were prepared to accept changes in the way they fished in order to remain in the profession. The commercial fishers were also prepared to accept a voluntary buy-out that would allow older fishers to take early retirement, and non issuance of any further commercial fishing licenses would reduce the number of commercial fishers, and eventually there would be no commercial fishers in Lake Macquarie.

The commercial fishers considered the main reason behind the decision to buy out commercial fishers was not based on environmental concerns, but was influenced by economic considerations (for example attracting tourism) and the decision was expedited by the recreational lobby group, within the constituency of the then Minister for Fisheries. This decision gave recreational fishers exclusive right of access to the coastal lakes of NSW. The decision resulted in the loss of 426 commercial fishing jobs in 29 lakes in 10 regions, with 36 of these from Lake Macquarie, which had direct negative economic impacts and social consequences. There were also many local jobs associated with the commercial fishing on the lake. For the commercial fishers in Lake Macquarie fishing was a profession, livelihood, chosen lifestyle, and the majority of fishers were not trained for any other form of employment, and therefore finding alternative employment, especially for the older fishers would be difficult. Most of the fishers were vulnerable to any change in economic circumstances as they were the sole earner in the family, paying off mortgages and had dependents. Commercial fishing was also an integral part off the character of the area and there was a loss of a cultural heritage which was part of the history of Lake Macquarie. The decision was controversial due to lack of in depth studies to determine effects of the proposals and the speed with which government departments acted upon the proposals. Initially, NSW Department of Primary Industries issue papers considered three options: continuation of commercial fishing; some restrictions on commercial fishing; and total exclusion of commercial fishing. However, at the public meetings there was no discussion with the stakeholders to seriously examine the viability of the first two options. The study by Momtaz and Gladstone (2008) revealed a number of significant social impacts that could have been avoided, minimised or mitigated. The proponent failed to detect the social impacts in advance as they did not conduct a Social Impact Assessment that would have helped identify potential issues, facilitate communication with the affected community, and the sharing of information.

(Momtaz and Gladstone, 2008).

Allocation of user rights and ITQs

Individual Transferable Quotas (ITQs) provide each individual operator with an annual share of the total catch that can be traded among operators. ITQs are primarily an instrument for promoting economic efficiency in a fishery rather than specifically for conservation (as discussed in Chapter 5). ITQs may result in the reduction of commercial fishing business accessing a fishery as the quota becomes consolidated among a smaller number of larger operators. While there are benefits from the introduction of ITQs, there are also a number of equity concerns, as it is often the small-scale fishers that exit the fishery, with associated social impacts in terms of total employment in fishing. ITQS are unable to account for the complexity and diversity of motivations and relationships in fisheries communities and the fishing industry. In managing fisheries under ITQ systems, governments may risk giving up too much power to the market. There can also be public concerns regarding equity in the implementation of ITQ systems (McPhee, 2008 pp. 98-100).

Following the introduction of individual transferable quotas (ITQs) in New Zealand and Iceland in the 1980s their use has been widely adopted in a number of countries including Australia (Grafton and McIlgorm, 2009). In Australia there is no comprehensive ITQ management approach involving all fisheries, instead the introduction of ITQs have been evaluated and applied on a case by case basis. In Australian, Commonwealth managed fisheries ITQs are viewed as best practice management. Their implementation is mandated unless there is a strong case made where it would not be cost effective, or otherwise detrimental. Grafton and McIlgorm (2008) argue that despite the importance of deciding whether the benefits of ITQs outweigh their costs, there has been no formal framework to help policy makers make these decisions. Grafton and McIlgorm (2008) developed a cost benefit and criteria framework aimed at showing whether the expected benefits of ITQs outweigh their expected costs. This framework was applied to seven Commonwealth managed fisheries where ITQs had been introduced. The results suggested that only the ETBF was deemed sufficiently large enough to warrant the introduction of ITQs. Some of the issues and considerations regarding the adoption of ITQs in a fishery are outlined in an example of the Tasmanian Rock Lobster fishery outlined below in box 7.4.3.2.

Box 7.4.3.2: Adoption of ITQs in the Tasmanian Rock Lobster Fishery.

ITQS were introduced into the Tasmanian Rock Lobster Fishery (TRLF) in 1998. The key objectives of the introduction of ITQs were to reduce the catch to sustainable levels and allow the stock to rebuild; and provide a mechanism for the industry to achieve economic sustainability. The results were successful for, both the restructuring and sustainability objectives, it reduced fishing effort by 29% and the number of fishing vessels by 23%; and the reduction of catch resulted in 6% increase in the estimated biomass and substantial increases in egg production. Fishers spent fewer days at sea, catch rates improved and these changes were expected to reduce fishing costs and increase profitability. However, the social costs resulted in fewer fishers employed on vessels (the direct loss of approximately 120 jobs). Fishers found it harder and more expensive to lease a fishing licence, as fishers had the added cost of leasing quota units or servicing loans to buy units. The average cost of harvesting in the fishery was estimated at about A$14 to $15 per kilogram, with the cost of leasing quota then A$12 per kilogram, the viability or profitability of each fishing operation depends, therefore on the ratio of owned to leased quota (Ford, 2001).

Four years after the introduction of ITQs there was a dramatic increase in the market price of quota units from those prior to the introduction (from less than A$1,000 in 1970s, A$4,000 in 1987, A$6,000 in 1991, A$10,000 in 1997) to A$25,000 in 2002. The value of 40 quota units, equivalent to the former full 40 pot licence package, was in excess of A$1 million. There was a trend toward increased ownership of quota units by non fishing investors and increased ownership by non Tasmanians. The high cost of quota units made it almost impossible for fish workers without capital to work their way up from deck hand to skipper and to acquire rights and become owner operators. The total market value of quota in 2002 exceed A$250 million. This reflected the capitalised value of the right by quota owners to claim approximately A$20 million in annual rent from the fishery. Nominally the resource remains publically owned and managed by the Tasmanian Government on behalf of the community, but in this case the strength of the vested interests associated with private property meant the Government was constrained in how it managed the fishery (Phillips et al., 2002).

The introduction of ITQs in the TRLF moved the fishery from a position of overcapitalisation to one of over-privatisation, with investor syndicates beginning to replace owner operators. The market was used as both a mechanism and an incentive for change by fishery managers as they restructured the fishery. Bradshaw (2004) argues there is however a difference between a mechanism and a plan. If the market which is a mechanism is mistaken for a plan then important social objectives risk being left out of consideration. Generally, the state is responsible for planning for the wellbeing of present and future generations in a fishery, therefore it is crucial that the state retains some agency in a fishery, rather than vest too much power in the market. According to Bradshaw (2004) the challenge for the Tasmanian Government is to reassert its rights, encourage a more responsible outlook from private right holders with whom it now has to share the fishery, which is made more difficult by the quota being owned by individuals in perpetuity with full transferability of rights (Bradshaw, 2004).

Harvest strategies

The failure to effectively implement precautionary harvest limits has led to many fishery managers implementing a rules based approach to the setting of total allowable catch (TACs), where total harvest or levels of escapement, are precautionary and avoid decisions that impose high ecological risks to the fishery. Quantifiable targets and reference points provide the means by which management actions can be evaluated and improved upon (Grafton et al. 2007). Performance of harvest strategies may be difficult to assess over short time frames, but the effectiveness may be indicated, for example by positive changes in stock status and a rebuilding of the stock, since the adoption of the harvest strategy (Cardin and Pastoors, 2008). According to Smith et al. (September 2007 p.3) a harvest strategy sets out the management actions necessary to achieve defined biological and economic objectives in a given fishery. Harvest strategies must contain a process for monitoring and conducting assessments of the biological and economic conditions of the fishery; and rules that control the intensity of fishing activity according to the biological and economic conditions of the fishery (referred to as control rules). Control rules are designed to keep the fishery on track in pursuit of its defined objectives, by specifying the management actions or decisions that need to be taken.

In Australia a fisheries harvest strategy policy has been developed for Commonwealth managed fisheries. There were a number of reasons for the development of the Commonwealth Harvest Strategy Policy (HSP). Throughout the 1990s and up to 2005 AFMA had managed fisheries in accordance with its legislative objectives, which were broad, but did not provide adequate guidance resulting in a range of possible outcomes, often leading to short-term decisions, that contributed to the decline of some fish stocks. There was an absence of clear links between the fishery assessment and management response. Indicators and reference points were adopted in a number of fisheries, but there was no consistency among fisheries or an agreed policy guideline on what these should be. Consequently, depending on which reference point used a stock could be classified as either over-fished or fully fished. It was against this background that the then Minister for Fisheries issued a Direction in December 2005 requiring all necessary steps to be taken to prevent further over-fishing, to recover over-fished stocks, and to manage the broader impacts of fishing on the marine environment (Rayns, 2007). The HSP complements the *Securing our Fishing Future* initiative (as outlined above) and was implemented in all Commonwealth fisheries, from 1 January 2008.

In September 2007 the *Commonwealth Fisheries Harvest Strategy Policy and Guidelines* for implementation of the HSP was released. The Harvest Strategy Policy provides a framework that allows a more strategic, science-based approach to setting total allowable catch levels in all Commonwealth fisheries on a fishery by fishery basis. The implementation guidelines provide practical advice on how to interpret and apply the Harvest Strategy Policy to Australia's fisheries and contain details of the science behind the fisheries management decisions (Department of Agriculture, Fisheries and Forestry, 18 August 2009).

The objectives of the HSP is the sustainable and profitable utilisation of Australia's Commonwealth fisheries in perpetuity through harvest strategies that maintain key commercial stocks at ecologically sustainable levels and within this context, maximise the economic returns to the Australian community. The (HSP) requires harvest strategies to be developed which pursue maximum economic yield (MEY) from each fishery, and ensure that stocks remain above levels at which risk becomes unacceptably high. Specifically, harvest strategies seek to: maintain fish stocks, on average, at a target biomass (B_{TARG}) equal to the stock size required to produce MEY (B_{MEY}); ensure fish stocks will remain above a biomass level where the risk to the stock is regarded as too high, that is, B_{LIM} (or proxy); and ensure that the stock stays above the biomass limit at least 90% of the time. In single and/or multi-species harvest strategies alternative reference points may be determined. In meeting all the outcomes harvest strategies are required to consider ecosystem interactions. The policy takes into account mortality resulting from all types of fishing (including recreational and state managed catches). Harvest strategies should be formally tested to demonstrate that they are likely to meet the core elements of the policy. Methods such as Management Strategy Evaluation (MSE) can be used to test both generic and species specific harvest strategies. The policy aims to provide for increased certainty and predictability in the operating environment for Commonwealth fisheries, therefore once strategies are established amendments should occur infrequently (every three to five years for most stocks), however if new information becomes available which substantially changes the understanding of the status of the fishery amendments may be necessary (Smith et al., September 2007 pp. 2-7). From an industry perspective they provide much more certainty about how management will respond to different situations.

According to Dowling et al. (2008) it is a challenge to develop harvest strategies for small and data poor fisheries (those which have only basic information, or no formal stock assessments, and where the future collection of data is limited due to costs restraints as these fisheries have low gross value of productions). In Australia a harvest strategy approach has been developed for low value and data poor Commonwealth fisheries. The approach is based on the following four general principles: the development of sets of triggers with conservative response levels, with progressively higher data and analysis requirements at higher response levels; identifying data gathering protocols and subsequent simple analysis to assess the fishery; archiving biological data for possible future analysis; and the use of spatial management either as the main aspect of the harvest strategy or to augment other measures. This approach was applied to a number of small-scale fisheries as case studies. The harvest strategies developed were precautionary and easy to understand by all stakeholders, and a mechanism for review was instituted to allow decision rules to be changed as more information became available. In developing the harvest strategies effective engagement of stakeholders underpins the successful development and implementation of the harvest strategies.

Marine Protected Areas and fisheries

Spatial management and temporal closures have a long history in fisheries management, but recently Marine Protected Areas (MPAs) have been promoted as potentially benefiting fisheries. As outlined by Ward et al. (2001, p. 1) the theoretical literature suggests that marine reserves and sanctuaries can provide important benefits to marine capture fisheries, provided they are appropriately designed, sited, and managed. However, empirical evidence indicates there have been few examples where the benefits to the fishery have been studied. Most studies focus on reserve improvements, when from a fisheries perspective the key issues are the type and extent of benefits derived by the fishery, such as catch, effort, profitability, socio-economic impacts in local communities and regional development. According to Hilborn et al. (2004) while marine reserves are a promising tool for fisheries management and conservation of biodiversity, they are not a panacea for fisheries management problems. Hilborn et al (2004) argue that area closures are just one tool of fisheries management and marine reserve implementation needs to be guided by scientific principles of adaptive management, experimental approaches, controls and evaluation. They need to be considered case by case, based on the objectives and the state of the fishery. They also need to be evaluated and compared to viable alternative fisheries management tools, and used, where appropriate, as one element in a broader package of measures. Initially there was a clear distinction between establishing MPAs for protection of biodiversity and those for fisheries management. More recently international stakeholders are calling for the large-scale implementation of MPAs (with up to 20-30% protection for oceans and elimination of consumptive uses within MPAs) on the basis that they will provide both conservation and fishery benefits, with little discussion on the potential costs.

7.4.4 Management and fishery assessments

Stock assessments and TACs

The success of a management system is often defined in terms of biological, economic, social and political objectives. However, the economic and social objectives will not be met if the stock is in a depleted state, such that the sustainability of the fishery is threatened. It is also unlikely the biological objectives will be met if the economic and social objectives are not considered (Beddington et al., 2007). Fish stocks are subject to natural variability and fish population can undergo changes in response to being fished (Haddon, 2001 pp. 1-4). The purpose of stock assessments are to determine how much fishing pressure a target species can withstand for the fishery to remain sustainable. Methods of fisheries stock assessment seek to estimate the levels of fishing mortality (and natural mortality) that can be balanced by recruitment and growth. The inputs to an assessment may be obtained from biological surveys (trawls, acoustics, tagging studies) and sampling (age and size composition); catch and fishing effort data; and fishery dependent data from log books. The methods and models used in stock assessments include dynamic surplus production models (equilibrium and non-equilibrium); models that include growth and mortality; age structured models; and simulation and ecosystem models. Forward projection models provide an opportunity for fisheries managers to review the effects of proposed management actions. The adoption of the precautionary approach requires fisheries management to consider risks and make clear the uncertainties. Risk assessment allows managers and stakeholders to evaluate a range of options with some knowledge of the likely consequences. Uncertainty is incorporated by providing advice in terms of probabilities of targets being met (Charles, 2001; King, 2007).

Total allowable catch (TAC) sets a maximum on the catch (generally total landed catch) allowed in the fishery for specific species, areas and time periods. Quotas are set through a stock assessment process. From a long-term biological point of view a TAC should reflect a sustainable yield estimated to minimise the risk of a stock becoming over-fished. It can also be set above or below this level to achieve specific management objectives such as fishing down a virgin stock to a desired level or rebuilding an over-exploited stock. TACs may be set and allocated under a fixed or variable quota system. Recruitment may vary from year to year in response to natural variability or from the effects of exploitation. The decision to manage under a fixed or variable system will be based on a trade-off between the extent of stock protection considered necessary and the objectives of maximising economic rent. If the TAC is not set appropriately it may lead to over-exploitation of the resource and sub-optimisation of the long-term economic rent generated from the fishery (Morgan, 1997).

Single-species and multi-species assessments

The management of single species has traditionally focused on the dynamics of a single targeted species which does not explicitly incorporate the effects of interactions with other species. The management of multi-species fisheries are characterised by the targeting of multiple species; the use of multiple gears; and the interactions with non-targeted fish species such as those caught as bycatch; potential impacts on predator prey relationships; or changes in age and size ratios. Single and multi-species models are directed at understanding and informing decision makers of the possible consequences of fishing activities. In particular direct mortality on target species and incidental mortality on other biota (which can be answered by single species models); and indirect effects related to changes in the flow of energy through the ecosystems (that will require multi-species models). Single-species assessments generally include a historical reconstruction of the stock to establish key parameters and relationships and to describe the current stock status (assessment); propose specific actions aimed at achieving a desired status (short-term forecasting); making long-term predictions of the likely future status of the stock under various management scenarios to establish desired outcomes (long-term forecasting); and advising on the robustness of management procedures (precautionary approach). Building upon single-species theory, dynamic multi-species models consider functional relationships among individual species in a fished system. Difficulties with implementing multi-species approaches are often due to the data intensive requirements. Multi-species models have improved the understanding of the dynamics of fish populations leading to improvements in single species models used to predict the impact of fishing on individual target species (Charles, 2001; Hollowed et al., 2000). Integrated Analysis (also referred to as statistical catch-at-age analysis) makes use of a wide variety of data sources. It is flexible in that it has the ability to represent different hypotheses about the population dynamics and the relationship between the data collected and the model predictions. It also separates the development of the model of the population dynamics from that of how the data are observed. It does not require continuous time series of data types i.e. catch at age data (Punt et al., 2006). Simulation testing revealed this is a robust assessment method for a variety of the SESSF species.

Fisheries strategic assessments

As discussed in Chapter 6 the implementation of the EPBC Act allows the Australian Government to assess the environmental performance of fisheries and promote ecologically sustainable management. The Sustainable Fisheries Section (SFS) is responsible for the assessment of fisheries managed under Commonwealth legislation and state export fisheries in accordance with the Act. The EPBC Act requires all Commonwealth managed fisheries to undergo strategic environmental impact assessments before new management arrangements are brought into effect, and for all fisheries (Commonwealth and state) with an export component undergo strategic assessment to determine the extent to which management arrangements will ensure that the fishery is managed in an ecologically sustainable way. Part 10 of the EPBC Act relates to strategic assessment of fisheries; Part 13, relates to assessments regarding impacts on protected marine species; Part 13A, relates to those fisheries requiring approval for the export of fisheries products (Department Environment, Water, Heritage and the Arts, 30 September 2008).

Risk assessments

Risk based assessments are included in the EBFM framework and these have been developed and applied to Australian fisheries. The majority of Australian fisheries are data poor and this has necessitated the development and application of qualitative risk assessment techniques to aid fisheries managers in making informed choices. Assessing risk is a key consideration for implementing the precautionary principle and dealing with uncertainty. A number of risk assessment approaches have been developed and most are based on the Australian Standards AS/NZS4360 (McPhee, 2008 pp. 214-216).

As part of the fisheries strategic assessment process an ecological risk assessment is required. A qualitative risk assessment was developed as part of the National ESD reporting framework (outlined further in Section 7.5.2). As Fletcher (2005a) outlines the concept of using risk assessment approaches to assist fisheries management is not new, but given the large number of potential issues that could be identified as part of the ESD process (many of which had minimum data), a method of assessing priorities was required. The risk analysis methods developed were based on the Australian and New Zealand Standard Risk Analysis, which were adapted for use in a fisheries context. The process involves the examination of the sources of risk (issue identification), the potential consequences (impacts) associated with each issue, and the likelihood (probability) of a particular level of consequence actually occurring. This combination produces an estimated level of comparative risk which can then be used to assist in determining the level of management response required. This approach considers target and vulnerable species; byproduct and other non-retained species; non-retained protected species; and ecosystems and habitats.

AFMA, in collaboration with CSIRO, initiated the project Ecological Risk Assessment for Commonwealth Fisheries (ERACF). This risk assessment approach considers the following five ecosystems aspects: target species; bycatch and byproduct species; Threatened Endangered and Protected (TEPs) species; habitats; and communities. The risk assessment framework involves a hierarchical staged approach. An expert judgement based scoping of the fishery, that moves from a comprehensive but largely qualitative analysis of risk at Level one, through a more focused and semi-quantitative approach at Level two, to a highly focused and fully quantitative “model-based” approach at Level three. Stakeholder engagement at each stage is important and provides an opportunity to gather more information on the fishery. Proceeding to subsequent levels depends upon estimated risk at the current level and management response at the current level (Hobday et al., 2007 pp. 1-6).

The aim in the scoping stage is to develop a profile of the fishery being assessed. Level one aims to identify which hazards lead to a significant impact on any component species, habitat or community. A “worst case” approach is used to ensure that elements screened out as low risk (either activities or components) are genuinely low risk. Where judgements about risk are uncertain, the highest level of risk that is still regarded as plausible is chosen. The Level two is based on the assumption that the risk to an ecological component will depend on two characteristics of the component units (species, habitats or communities). The extent of the impact due to the fishing activity will be determined by the susceptibility of the unit to the fishing activities; and the productivity of the unit, that will determine the rate at which the unit can recover after potential depletion or damage by the fishing. This analysis essentially measures potential for risk. At Level three the risk assessment is fully-quantitative and relies on in-depth scientific studies on the units and is both time and data-intensive (Hobday et al., 2007 pp. 1-6).

Management Strategy Evaluation

It is at the operational level, through management strategies, that the broad policy goals are linked to individual management actions. The general framework for management strategies is described in many guidelines and standards, such as the International Organization for Standardization (ISO) 14000 for environmental management, which emphasise evaluating the performance of the management system as a whole (International Organization for Standardization, 2009). The traditional fisheries management approach involves assessment of the status of the resource used to recommend a control measures such as a TAC based on a harvest control measure, often associated with a biological reference point. The Management Strategy Evaluation (MSE) approach for providing TAC recommendations involves simulation testing of the whole process within an adaptive management framework. Scientific uncertainties are explicitly taken into account, within a risk-based framework, and the application of the precautionary approach (Butterworth and Punt, 2003).

The MSE approach has also been extended to ecosystem-based management. The goals of MSE are to support an informed selection of a management strategy, to make clear the trade-offs among the management objectives for any given strategy, and to identify the requirements for successful management. MSE generally focuses on the performance of the fishery in the medium to long-term; compares the performance of several alternative management strategies; accommodates multiple and diverse performance indicators (including social, economic and biological); allows exploration of adaptive management strategies with dynamic feedback; and provides a framework for comparing the prospect of different stakeholder objectives being realised. In Australia MSE has been applied to single and multi-species fisheries harvest strategies, the wider ecological issues of non-target species and habitats, spatial management and more recently for providing scientific decision support for multiple use management of coastal regions and estuaries (Smith et al., 1999 p. 971; Sainsbury et al., 2000 pp. 732,738-739; Butterworth and Punt, 2003; Dichmont et al., 2008 p. 238; Mapstone et al., 2008 pp. 315-326; McDonald et al., 2008 pp. 401-402).

7.4.5 Industry fishery assessments

Environmental Management Systems

In Australia 'Take your pick! - *the Seafood EMS Chooser*' was developed by Seafood Services Australia Ltd, for the seafood industry, and is applicable to fishing, aquaculture and the post-harvest sector of the industry. It was designed to assist the fishing industry to develop an Environmental Management System (EMS), based upon the National ESD framework and was designed to complement this. It puts in place a process of planning, implementing, reviewing and improving the actions that an organisation undertakes to manage its risks and opportunities. These include those relating to the environment; food safety and quality; occupational health and safety; profitability; public relations; and other aspects of the organisation (Seafood Services Australia Ltd, 2005 pp. 1-7).

As discussed by Fletcher (2006) a number of EMS have been developed by fishing industry groups in Australia. An industry-level EMS can be used to describe how an individual company, or a corporate group within a fishery or fishing area, is attempting to meet the ESD principles relevant to its activities. The company or group can describe how it will meet some, or all, of the management requirements dictated either directly by relevant regulations, or indirectly as a response to community expectations. This approach can be informal, such as a set of codes of practice, or more formal and include third party auditing. Interest in EMS is due mainly to industry's recognising that some form of environmental accreditation may help maintain its longer term market access, particularly in areas where competition for access to resources is high. An industry-level EMS will, however, generally not be able to deal directly with all elements required for the management of a fishery. Industries do not administer the development of relevant legislation and regulations and generally do not monitor the performance of the affected target stocks. These responsibilities are usually undertaken by the relevant fisheries-management agency on behalf of the community.

Accreditation and eco-labelling

Voluntary eco-labelling and the Marine Stewardship Council (MSC) accreditation scheme were outlined and discussed in Chapter 5 Section 5.3.2. Those Australian fisheries that have been accredited under the MSC scheme, are the Western Australian West Coast Rock Lobster Fishery; the Mackerel Icefish fishery; and the South Australian Lakes and Coorong fishery. In Australia an alternative to the MSC approach is the Clean Green Program was launched in 2004. It is an independently audited and integrated environmental management system that incorporates product certification standards (environmental, food safety and quality, work place safety and animal welfare) program, from pot to plate, for the Australian southern rock lobster industry. Since its successful launch and positive feed-back from the Tasmanian and Victorian fishing industries and their associations, a number of fisheries have been certified under the program, which is also supported by the Australian Government. As part of their Sustainable Fisheries campaign, the Australian Marine Conservation Society developed a guide to choosing sustainable seafood for consumers who want to make informed choices when buying seafood in Australia (Petrachenko, 2007 pp. 1-10). Seafood Services Australia has released a guide to environmental labelling and is looking at developing its own environmental labelling scheme, which would rely on the environmental performance that a fishery has achieved as part of the fisheries strategic assessments requirement under the EPBC Act (Bishop, 2008 p. 19).

As discussed by Petrachenko (2007) the fishery managers and industry representatives have also expressed an interest in using the fishery strategic assessment under the EPBC Act, as an eco-labelling marketing tool, but in its current form it is insufficient to support an eco-label. There is often confusion over the intent of the strategic fishery assessments, and the question of aligning the EPBC Act assessment process with existing fishery accreditation schemes. A fishery assessment would only be one component of an eco-label scheme. As the fishery assessment does not itself confirm or establish the ecological sustainability of the fishery or any particular species taken in the fishery, it assesses the capacity of the management arrangements to ensure ecological sustainability. To be credible any eco-labelling schemes would need to meet the International Organisation for Standardization (ISO) standards; determine the chain of custody requirements; and be verified by an independent third party. Essentially an eco-label is a marketing tool, not a means of environmental management. From a policy perspective the eco-label aims to educate consumers about sustainability of the product and to influence or change purchasing behaviour. From an industry perspective eco-labels can distinguish fish products, with the expectation of greater market share, and profits (Petrachenko, 2007 pp. 11-14).

7.4.6 Data and information

EBFM requires a wider range of both qualitative and quantitative information that has to be incorporated into any decision-making processes. An issue regarding data and information is that of information and knowledge sharing. The FAO (2009a) developed a set of technical guidelines for responsible fisheries; this was in response to situations where the lack of essential information is a major constraint to the implementation of the Code of Conduct for Responsible Fisheries. The guidelines highlight the issues involved in the flow of information between the different stakeholder groups, as well as presenting some of the constraints involved in the cycle of creation, production, dissemination and availability of information and knowledge, and data sharing. The guidelines also refer to the different types of information needed. Tracking the existing flows of information highlights gaps and barriers, both in dissemination and accessibility. This applies to the content and format of information as well as the institutional and infrastructure issues. The data and information that form the knowledge base of fisheries and aquaculture are continually changing and extending as gaps are identified, and subsequently filled by research, and this information is essential for informed decision-making, and facilitates learning (Food and Agriculture Organization (FAO) of the United Nations, 2009a pp. xv-2). The FAO acknowledges that information requirements are not easy to fulfil especially for small fisheries. The creation and integration of multi-disciplinary knowledge, whether research based or traditional, is complex. Fisheries information is broad and multi-disciplinary; it has depth in terms of time and perspective; it involves various scales from local to global; and it comes from a complex mix of sources. Information produced by different sources and disciplines may at times be contradictory and these features lead to challenges in using fishing information (Food and Agriculture Organisation (FAO) of the United Nations, 2009a pp. 3-13).

Data and information issues are a challenge for Australia, as highlighted in the various policy reviews and State of the Environment reporting, and the 1998 (Sainsbury, Smith and Webb, 1998) and 2008 (Webb and Smith, 2008) reviews. The issues of data, monitoring and reporting have also been outlined in a peer reviewed report the *Progress in accessing environmental data and information* (Department of the Environment and Heritage, 2006), and a summary of findings from this report is presented below.

Institutional barriers continue to prevent efficient use of the data that is available within Australian agencies and jurisdictions. These barriers include the lack of trust, or agreement between agencies and jurisdictions about who has responsibility for the collection, management, reporting and analysis of data. There is a lack of co-ordination within jurisdictions and agencies, leading to fragmentation of monitoring efforts within and between agencies in all jurisdictions. There is a mis-alignment between the needs of the information users and the objectives of the information providers; and confidentiality, privacy and commercial concerns that increasingly impede access to the data available within agencies. Although co-operation appears to have improved across Australian Government agencies, this is not necessarily filtering down to lower levels where, for example, copyright and licensing issues have impeded the collegial sharing of data between agency staff. In 2006 there were still gaps in primary environmental data for marine resources and gaps in fundamental datasets for environmental monitoring. Some data cannot be aggregated and compared on a continental scale because of failure to standardise differences in scales, map projections, boundaries and geographical divisions, and inconsistencies in the way attributes are described and recorded (Department of the Environment and Heritage, 2006).

Some environmental data are intrinsically challenging to collect, hence, the focus of data gathering has been, at the level of population and distribution of individual species and, to a lesser extent, on the distribution and character of ecological communities. Australia does not have a comprehensive understanding of whether changes in the distribution and abundance of any particular species, reflects positively or negatively on biodiversity as a whole. To resolve these issues requires a more systematic approach to environmental data collection and monitoring. This would involve communication and collaboration between all jurisdictions in developing co-operative frameworks for information collection, access and use, and requires investment in national data management infrastructure (Department of the Environment and Heritage, 2006).

7.4.7 Research

In Australia research funding for Commonwealth and state managed fisheries is provided by different government departments and agencies such as the Fisheries Resources Research Fund (FRRF); Department of Agriculture, Fisheries and Forestry (DAFF); Bureau of Rural Sciences (BRS); Australian Bureau of Agriculture and Resource Economics (ABARE); Australian Fisheries Management Authority (AFMA); Department Environment, Water, Heritage and the Arts (DEWHA); Fisheries Research and Development Corporation (FRDC); and Australian Commonwealth Scientific and Research Organisation (CSIRO). Research providers include agencies such as BRS; ABARE; CSIRO; state fisheries agencies e.g. the Department of Fisheries W.A.; universities; and independent providers.

Several organisations and groups also play a co-ordinating role, such as the Australian Fisheries Management Forum (AFMF). The Australian Government's Oceans Policy Science Advisory Group (OPSAG) promotes co-ordination and information sharing between Australian Government marine science agencies and the broader Australian marine science community. The Marine and Coastal Committee (MACC) advises on marine and coastal matters. MACC has a number of working groups including the Intergovernmental Coastal Advisory Group (ICAG), the Biodiversity Working Group (BWG) and the Research and Development Working Group (RDWG). These advise MACC on key national marine issues and strategies across their different sectors (M. Haward and D. Smith 2010, pers. comm. 23 February 2010).

The Australian Fisheries Management Forum (AFMF) is a consultative committee, which aims to ensure high level inter-agency collaboration of issues of mutual benefit and interest. The Fisheries Research and Development Corporation (FRDC) is responsible to stakeholders to plan, invest and manage fisheries research and development throughout Australia; and to facilitate the dissemination, adoption and commercialisation of research and development results. Where a number of related research and development projects could be better managed through co-ordination and integration, than for individual projects, FRDC, either on its own initiative, or at the request of a stakeholder group, has established a managed subprogram, for example, the Ecologically Sustainable Development (ESD) Reporting and Assessment, and more recently the Social Sciences Research Co-ordination Program (SSRCP).

7.5 Reviews of Australian fisheries 1998 and 2008

Two reviews of ESD and EBFM, in Australian fisheries, have been undertaken, the first in 1998 (Sainsbury, Smith and Webb, 1998), and the second in 2008 (Webb and Smith, 2008). The 2008 review provided an opportunity to repeat the 1998 national snapshot of experience and approaches across jurisdictions, for the period from 1998 to 2006. The results and outcomes from both reviews are presented and discussed below.

7.5.1 The 1998 review

One aspect of the NSESD strategy was to develop and apply sustainability indicators to measure performance against ESD objectives. Indicators are used for a number of purposes such as in fishery management plans; statutory reporting requirements or government audits. Despite the widespread use of sustainability indicators across all fisheries management jurisdictions there was limited understanding of the experience and approaches taken by each jurisdiction, and little evidence of consistency of approach. This situation initiated the 1998 review. The aim was to provide a comprehensive outline of how sustainability indicators were being used, and to identify areas of national agreement or significant contention about future directions. The review was to include comprehensive consultation with the peak industry bodies, fishery management agencies and FRDC Fishery Research Advisory Bodies (FRABs) in all jurisdictions. The specific topics for review were the current status of the use of sustainability indicators; planned development in the use of sustainability indicators; and future directions in the use of sustainability indicators, gaps and implications for research and development. The methods used included a questionnaire; and follow-up interviews were arranged. The interviews were to ensure that the questionnaire responses fully reflected the range and depth of ideas and activities occurring across Australia. Fishery management documents (fishery management legislation, fishery management plans, institutional strategic plans, and fishery status reports) were also reviewed to identify the use of indicators related to ESD objectives, and in some cases, discussed during the interviews (Sainsbury, Smith and Webb, 1998 pp. 4-8).

A major recommendation was the development of a nationally co-ordinated research and development program on sustainability indicators. The national program would develop options for sustainability indicators and guidelines for their use that were acceptable to all jurisdictions. The program would be linked to the Standing Committee on Fisheries and Aquaculture (SCFA) processes and was inclusive of all jurisdictions (Sainsbury Smith and Webb, 1998 p. 1). Specific recommendations from the review highlighted four main areas needing research and development. These needs, and the suggested approaches to meeting them, were:

1. Define terminology and framework for indicators of ESD performance. A guide was needed to define the terms used in relation to sustainability indicators and to provide a consistent framework for their use. The review began the process of developing a consistent terminology and use for sustainability indicators. This work should be completed, and a guide produced that was acceptable to all jurisdictions.

2. Capture experience nationally and internationally. The experience of what had been tried and the results to be critically reviewed (addressing outcomes, not just report on existing practices) and consolidated nationally and internationally for fisheries and other sectors.

3. Develop guidelines for using sustainability indicators. A working group should develop national guidelines for using sustainability indicators. It should draft the scope and criteria for the guidelines, and submit them to SCFA and individual jurisdictions for consideration. Once the draft was agreed, the working group should oversee and guide the developing and testing of options for sustainability indicators.

4. Develop and test options for sustainability indicators. The consolidation of existing experience was a necessary preliminary to developing a national approach to using sustainability indicators. As it would increase mutual understanding among Australian jurisdictions, provide ideas for indicators, and some indication as to their appropriateness in different circumstances.

> Simulation testing across a range of realistic but standardised fishery and ecological situations was also required to understand the performance of sustainability indicators in different situations and the degree of precaution required. The results would be used to tabulate the relative risks of using various sustainability indicators in particular fishery situations. Together the meta-analysis and simulation testing would enable sustainability indicators to be selected and justified in a risk management context (Sainsbury, Smith and Webb, 1998 p. 1).

7.5.2 Work undertaken by the ESD subgroup since the 1998 review

While the high level objectives of ESD are relatively simple in concept, translation of these high level objectives into operational objectives at the fishery management level has proved difficult to achieve, both in Australia and elsewhere. As outlined in Chapter six, Section 6.3, in Australia most fisheries agencies had performance measures for some components, particularly those related to the biological sustainability of target species. Without clear operational objectives, indicators and performance measures for all aspects of ESD, it was difficult for fisheries management agencies to demonstrate that they were achieving ESD (Smith and Hodge, June 2001 p. 1).

An ESD stakeholder workshop was held in Geelong during March 2000. It was recognised that there was a need to progress from the current situation, to where reporting on all components of ESD could be completed. Endorsement was obtained from all sectors for the SCFA approach (Smith and Hodge, 2001). As a result FRDC supported the development of the SCFA approach. This included the *Framework for assessing performance against the ESD objectives of Commonwealth fisheries management* (Chesson and Clayton, 1998) to determine how well ESD requirements were being met and the development of the BRS framework based on component trees, which included the ecological, economic, social and governance; and the *National ESD Reporting Framework for Australian Fisheries: Technical Support Document – Ecological Components of the 2000/2001 Case Studies* (Whitworth et al., 2002) where the framework was applied to eight Commonwealth fisheries.

Under the FRDC Ecologically Sustainable Development Reporting and Assessment (ESDRA) Subprogram, a number of national methods and tools were developed. These include national reporting methods for wild capture fisheries and aquaculture; a method for conducting ecological risk assessments; a social assessment handbook; and a template for meeting EPBC Act guidelines for export fisheries as listed:

- *National ESD Reporting Framework for Australian Fisheries: The 'How To' guide for Wild Capture Fisheries* (Fletcher et al., 2002).
- *National Application of Sustainability indicators for Australian fisheries* (Fletcher et al., 2003).
- *National ESD Reporting Framework: The 'How To' Guide for Aquaculture* (Fletcher et al., 2004).
- *Social Assessment Handbook: a guide to methods and approaches for assessing the social sustainability of fisheries in Australia* (Schirmer and Casey, 2005).
- *ESD Reporting and Assessment Subprogram: a social assessment handbook for use by Australian fisheries managers in ESD assessment and monitoring* (Schirmer, 2005).

These and other ESD publications can be found on the national website (National Fisheries ESD, 2010).

To demonstrate ESD is being addressed requires an appropriate conceptual framework that maps out how the general ESD objectives will be applied in the fisheries context; the scope of the issues which will be addressed; and how progress will be reported and assessed. The National ESD reporting framework for wild capture fisheries has resulted in a practical system that allows reporting on all levels of ecologically sustainable development, the environmental, economic, social and governance components for each fishery (Fletcher et al., 2005). The framework is based on the component trees within the three main categories of contributions of the fishery to ecological well-being (retained and non-retained species and the general ecosystem); human well-being (Indigenous, community and regional, social and economic); and factors affecting the ability of the fishery to contribute (impact of the environment on the fishery, governance arrangements). The design of the ESD reporting framework has been improved by developing a set of generic component trees (Fletcher et al. 2005). There are four main steps to complete an ESD report for a fishery:

- Step1. Identifying the issues using component trees.
- Step 2. Prioritisation of issues using a qualitative risk assessment.
- Step 3. Completing component reports.
- Step 4. Compilation of report.

Figure 7.5.2 below outlines the Summary of ESD framework process (Further details are presented in Fletcher et al., 2005).

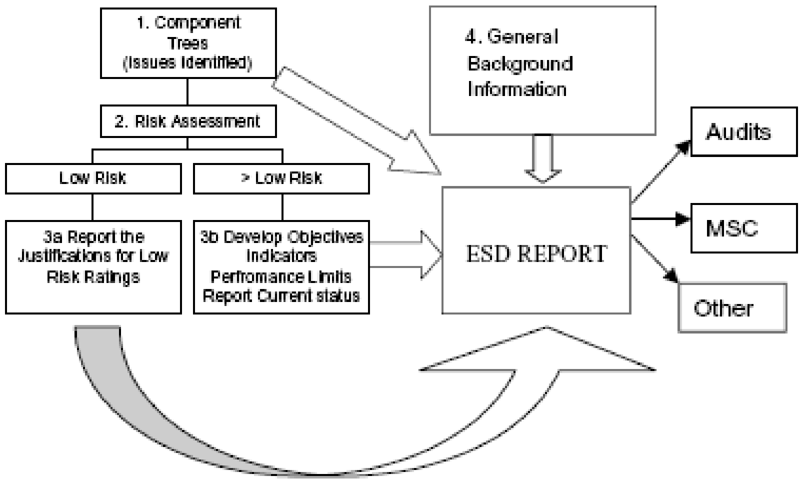


Figure 7.5.2: Summary of the National ESD Reporting Framework (after Fletcher et al., 2005).

The social assessment handbook provides a guide to methods and approaches for assessing the social sustainability of fisheries in Australia. According to Schirmer (2005) understanding the social side of fisheries and the fishing industry has received little attention, but is becoming increasingly important, particularly as part of the process of reporting on ecologically sustainable development. Assessing social impacts can help in choosing between management options that have similar resource and economic outcomes, but may have a range of different social impacts. It can also assist in developing appropriate policies for assisting necessary social transitions associated with any changes implemented in the fishing industry (Schirmer, 2005 p. 1). The handbook provides useful measures and indicators for profiling fishing communities and discusses the types of data (primary and secondary) that can be used and collection methods. Three important types of data are required: social capital which can measure quality of life, community wellbeing and resilience; values, attitudes and beliefs, that help to identify social goals important to different communities; and spatial relationships linking aquatic resources and fishing communities, to identify the different communities that are dependent upon particular aquatic resources, and differences in social conditions within and between communities (Schirmer and Casey, 2005 pp. 1-4, 44-45).

Another initiative to over-come the lack of social data and to capture social information nationally was the *Marine Matters: the National Atlas of Australian Marine Fishing and Coastal Communities* launched on 26 September 2006. The Atlas is the first Australia-wide, comprehensive and authoritative mapping initiative presenting an overview of Australian fishing activities and coastal communities. The Atlas shows where fish are caught in Australia's oceans, the value of those catches, where different fishing gears are used and the species that are taken. It also provides information on the socio-economic characteristics of coastal communities in eight Marine Regions around Australia. The Atlas has been produced to inform decision makers responsible for the management of activities in Australia's marine waters, and to aid the Australian and state and territory governments in developing and implementing policy initiatives. It is also a flexible and readily accessible information source for anyone with an interest in the management of Australia's marine estate (Larcombe et al., 2006).

Summary of jurisdictional uptake of ESD framework as at 2004

The outcomes from the first three years of operation of the ESD Subprogram were considered very successful (Fletcher 2005b; Webb and Smith 2008). The tools and methods (as listed and discussed above) were developed to measure and assess the performance of fisheries across the full range of ESD issues. This work was seen as leading the world in the implementation of ESD and EBFM. The ESD reporting framework and the guidelines provided the ability for agencies and the industry to complete detailed management assessments against all ESD principles for individual fisheries. The next step is to develop the tools needed to enable assessments of multi-sector fisheries and to facilitate multi-sector assessments that could assist with marine planning issues. Another key outcome from the discussions held by the ESD Subprogram was the generation of a set of agreed ESD terminology; these definitions were agreed to by the Australian Fisheries Management Forum and the Marine and Coastal Committee of the Natural Resources Management Standing Committee. This covered terms such as Environmental Management Systems (EMS), Ecologically Sustainable Development (ESD), Ecosystem-Based Management (EBM), Ecosystem Based Fisheries Management (EBFM) and Integrated Oceans Management (IOM) (Fletcher, 2005b pp. 5-6).

At each of the ESD Reference Group meetings, the representatives from each jurisdiction provided an update of the uptake of the tools developed by the ESD Subprogram. This update was both on the level to which they were using the ESD framework, and more specifically, in generating their applications to meet the EPBC strategic assessment requirements. The presentations by each jurisdiction indicated that the level of uptake varied according to the jurisdictional requirements and the level of resources available. All jurisdictions agreed that these tools affected their processes and outcomes in a positive fashion. The following is a summary of uptake of the national ESD reporting framework as at mid 2004 (Fletcher, 2005b p. 33):

- *Western Australia*: all strategic assessment applications had been submitted and all used the ESD framework to develop the applications;
- *South Australia*: is now in the process of using ESD framework to update existing management plans and develop new plans. The framework has been used to generate status reports for SA fisheries;
- *Victoria*: ESD Framework has already been used for the development of some management plans (including some consideration of economic and social objectives);
- *New South Wales*: elements of national framework were used where appropriate (given specifics of guidelines needed for NSW planning approvals);
- *Tasmania*: DPIWE and TAFI had been investigating the incorporation of the socio-economic component of ESD framework within the current stock assessments. Also taking the first steps towards formally embracing other processes such as ESD framework within Fisheries Management, but were

unsure of what alternative frameworks were available and how to incorporate these within the current process;

- *Queensland*: the then current round of ecological sustainability reporting to Commonwealth DEH did not utilise the ESD framework. Now using the risk assessment elements of the ESD framework, but still a need to educate fishery managers about the benefits of using the ESD framework for management planning; and
- *AFMA Commonwealth fisheries*: the framework hasn't strictly been adopted but the concepts are included. Phase one of an alternative ERA had been completed, with phase two about to begin. There were oncern that there may be ramifications of leaving out the social and economic aspects in the application of strategic assessments under the EPBC Act (Fletcher, 2005b pp. 34-35).

7.5.3 The 2008 review

The second review published in 2008 the *Review of the scope, assessment methods and management responses for fisheries ESD and EBFM in Australia* (Webb and Smith, 2008) provided an opportunity to repeat the national snapshot of experience and approaches across jurisdictions for the period 1998 to 2006. The objectives of the review were to:

1. Compare and contrast the scope, principles and criteria of fisheries ESD and EBFM.
2. Review and report on the major issues raised from the Environment Protection and Biodiversity Conservation (EPBC) strategic assessment process for ESD and EBFM, and implications for research and development.
3. Review the recent developments in fishery assessment methods, indicators and benchmarks used in Fisheries ESD and EBFM assessments and their state of development, and develop agreed directions on future assessment processes by end users.
4. Review the response by fishery management agencies and Fisheries Research Advisory Board (FRABs) to the fisheries ESD and EBFM assessment methods,

their status, development and future directions, and identify gaps and implications for research and development.

5. Identify possible bottlenecks for implementation and cost implications to fisheries.

6. Develop and deliver presentations and ‘plain English’ written summaries of the results of the review to Commonwealth and state fisheries departments and other relevant Commonwealth agencies.

As part of the review a survey was undertaken of the management responses to ESD and EBFM in Australia (Webb and Smith, 2008 pp. 5, 9).

7.5.3.1 The Survey: where we were, where we are now, where we need to be

The purpose of the survey was to collect the relevant information to review the current experience and management responses for fisheries ESD and EBFM in Australia, for each jurisdiction. The survey comprised five sections as summarised below (Webb and Smith, 2008 pp. 18-19).

Section two of the Survey explored how fisheries management responses had changed with regard to ESD and EBFM within jurisdictions from 1998 to 2006 for the following areas of interest:

- progress towards incorporating ESD and EBFM operational measures into policy, planning, legislation and management arrangements for the environmental, economic, social and governance components of ESD;
- identifying the level of confidence in managing the environmental, economic, social and governance components under ESD and EBFM principles; and
- indications of where performance indicators and benchmarks were/are being used for environmental, economic, social and governance components.

Progress in application, use and confidence was reported in all these areas from 1998 to 2006. However, for both 1998 and 2006 there were variations of application, use and confidence across the environmental, economic, social and governance components, and within and between jurisdictions. It was interesting to note that for all components there were differences between research and management views on levels of implementation. The majority of research responses considered implementation to be not as far advanced as the management responses reported. As a follow up it would be useful to find out the reason for these variations in application, use and confidence in terms of whether variations are related to particular issues within components; are related to particular issues within jurisdictions; and why there is a difference in views between management and research on application, use and confidence (Webb and Smith, 2008 pp. 19-20).

Overall the results between 1998 and 2006 for the general pattern for application, use and confidence by component from highest to lowest were:

- target species component;
- byproduct, bycatch, TEPs species and governance components as a group;
- habitats, ecosystems/communities and economic components as a group; and
- the social component.

Section three of the Survey aimed to establish the status of fisheries management responses to ESD and EBFM within jurisdictions in 2006. One of the areas of interest was the use of assessment and management tools. For all jurisdictions in 2006 there was a wide variation in use of assessment and management tools across components and within and between jurisdictions. The use of assessment and management tools varied, in terms of those tools most used, and those least used. Overall results for all jurisdictions in 2006 regarding the use of assessment and management tools is ranked in the table 7.5.3.1 below (from most used = 1 to least used = 6).

Table 7.5.3.1: The use of assessment and management tools.

Risk assessment	Qualitative assessment	ESD reporting framework	Quantitative assessment	Indicators	Benchmarks	EMS	Decision rules	Harvest strategies
1	1	2	3	3	4	4	5	6

A number of other tools were reported as being used, such as fisheries management plans, or those under development such as codes of practice and conduct; and co-management processes. There were variations in the application of assessment and management tools as applied to the different components. Generally for all jurisdictions in 2006, the use of assessment and management tools in managing components (from most used to least used) by component was:

- target species component;
- byproduct, bycatch, and threatened, endangered or protected species (TEPs) species components;
- habitat, community/ecosystems and economic components as a group; and
- social and governance components (Webb and Smith, 2008 pp. 20-21).

Section four identified what was needed for further development over the following six years from 2006 to 2012, in order to better implement ESD and EBFM. The focus was on:

- the key issues/challenges for implementation of ESD and EBFM for the environmental, economic, social, governance components;
- what management and assessment tools will need to be available and in routine use by 2012 for the environmental, economic, social, governance components;
- possible bottlenecks for successful implementation of ESD and EBFM;
- cost implications of implementing ESD and EBFM for fisheries (both time and money); and
- the data, analysis, research and decision support needed to properly implement ESD and EBFM (Webb and Smith, 2008 p. 22).

The key issues/challenges for implementation of ESD and EBFM for the environmental, economic, and social and governance components, and other important points (collated from the survey and summarised below) were as follows:

- data and information needs: regarding target, byproduct, bycatch and TEP species, habitat and community components, and further research for understanding the interactions between them;
- economic: identifying economic issues/impacts requiring management; data collection and analysis for the development of useful management objectives, performance indicators, benchmarks and monitoring;

- social: identifying social issues/impacts that need to be considered; data collection and analysis for development of meaningful management objectives, indicators, benchmarks and monitoring; and
- governance: resources for rationalisation and streamlining of governance arrangements and processes to support management and compliance, and also to ensure that the environmental, economic and social components can be managed effectively within Australia (Webb and Smith, 2008 p. 22).

The management and assessment tools which needed to be available and in routine use by 2012 for the environmental, economic, social, governance components (collated from the survey and summarised below) are as follows:

- environmental: risk assessments (including cumulative risks), indicators and decision rules, monitoring programs, qualitative and quantitative models, and simplified management strategy evaluation tools;
- economic: risk assessments, indicators, and assessment tools (for all fishery sectors);
- social: risk assessments, indicators, and assessment tools (including impacts of change);
- governance: EMS and harvest strategies for major fisheries, framework for allocation between fishery sectors, adequate reporting, benchmarking for ESD, and a review of Offshore Constitutional Settlement (OCS) arrangements for management of species across jurisdictions (Webb and Smith, 2008 p. 23).

A number of possible bottlenecks were identified which are likely to affect the successful implementation of ESD and EBFM. These were categorised under the following headings: funding and associated costs; resources and people; governance/management systems and the EBFM framework; and data/information/research needs as collated from the survey and summarised below:

- funding and associated costs: for research and data, tools development, management processes to further develop EBFM, and the issue of cost recovery from fishery sectors;

- resources and people: capacity in terms of time and people for implementation of EBFM;
- governance/management systems: cross jurisdictional (within and across departments, agencies and jurisdictions) clarity in the scope and objectives and outcomes to be achieved for whole of government approach in implementing EBFM; and
- data, information, and research needs (Webb and Smith, 2008 pp. 23-24).

A range of time and costs implications were identified for implementing ESD and EBFM for fisheries, which affect research, management and industry, collated from the survey and summarised below:

- research: the development of environmental, economic and social components under EBFM principles, requires multi-disciplinary teams and may require employing more research staff;
- management: increased management and monitoring costs, EBFM process takes time to develop, consult and implement, requires efficient processes between the Commonwealth and states; and
- industry: commercial fisheries are the only sector that contributes to management, research and compliance on a cost recovery basis, and costs are incurred now, but benefits will not be immediately recognisable (time lag between investments and benefits) (Webb and Smith, 2008 p. 24).

To implement ESD/EBFM the following data, analysis, research and decision support requirements were identified, collated from the survey and summarised below:

- data: increased spatial and temporal data for species, habitats and communities and ecosystem linkages, social and economic data, different data types for decision-making tools and assessments, standardising data collection between jurisdictions, integrated databases, and improved data management and sharing;
- analysis: with increased data needs a corresponding requirement for analysis, and new and novel approaches to data analysis for decision support;

- research: filling information gaps for all components (ecosystems, economic and social), developing indicators, tools (including rapid assessment tools for low value and data poor fisheries) and monitoring approaches; and
- decision support: revised fishery models, management strategy evaluation framed in the context of ESD and EBFM, a commitment to use the triple bottom line approach to decision-making, and the development and better understanding and use of performance indicators (Webb and Smith, 2008 p. 24).

Section 5 provided an opportunity for the respondents to include further comments, regarding ESD and EBFM implementation.

7.5.3.2 Summary of recommendations

A key recommendation was a widespread view that there was an ongoing need for a national forum to co-ordinate approaches to EBFM, which brings together a range of stakeholders involved in the development and implementation of EBFM, including fishery managers, industry, environmental agencies and non-government organisations (NGOs), and various disciplinary experts. The recommendations of the review were categorised under the following headings (Webb and Smith, 2008 p. 2):

1. Co-ordination and consistency

The need for improvements in co-ordination and consistency in approach across fisheries, jurisdictions and departments:

- apply to the extent possible a consistent approach to EBFM across all jurisdictions to co-ordinate management of shared resources and cumulative impacts, and to assist in national reporting;
- co-ordinate and collaborate across fisheries and between jurisdictions to optimise research and development costs and time;
- integrate and streamline where possible processes and reporting requirements to over-come the identified issues of fit, overlap and duplication;
- identify regional marine planning (state and Commonwealth) requirements, and explore whether it would be worthwhile to amend current ESD and EBFM reporting frameworks to accommodate these needs; and

- work with Department of the Environment, Water, Heritage and the Arts (DEWHA) to ensure fisheries-relevant and consistent approaches to strategic assessments.

2. Development of tools

There are considerable variations in use of assessment and management tools by ESD components, and variations within and between jurisdictions in use of assessment and management tools:

- a plan for further development of indicators and reference points, focusing first on those areas where least progress has been made;
- develop a suite of tools (tool box) for monitoring, assessment, and decision support, spanning from rapid, qualitative methods through to full quantitative approaches; and
- clarify why there is a difference in perception between researchers and managers on the adoption of tools for EBFM.

3. Resources and capacity

A key issue/challenge for implementation of ESD and EBFM across all jurisdictions is the need for adequate resources (funding and people) and data, analysis, research and decision support:

- identify efficient and cost-effective solutions to address data, information, research and decision support needs; and
- provide a framework that allows effective prioritisation across competing demands for resources to support implementation of ESD and EBFM.

4. Training and communication

Closely linked to capacity is the need for education and training for fisheries managers, industry and researchers to enable them to develop a set of skills that better match the expected roles and responsibilities necessary for implementing EBFM:

- expand existing training programs both at the tertiary level and for current fisheries managers, peak bodies and advisory groups to meet specific needs of implementing ESD and EBFM; and
- build on lessons learned from ESD Subprogram to improve communication of principles and practice of ESD/EBFM.

Webb and Smith (2008) found that implementation of these recommendations would require careful co-ordination at two levels. First, the continuation of a high level national process and forum involving key stakeholders in policy, management, industry, environmental non-government organisations (NGOs) and key government agencies. Second, a smaller, adequately resourced, and more dedicated team tasked with implementation and co-ordination of key recommendations. Such an approach is most likely to address the issue of consistency of processes and approaches within and between jurisdictions; make best use of limited funding for the development of tools and meeting data and research needs; identify capacity shortfalls and bottlenecks; and create a coherent way forward within realistic timeframes.

7.6 Discussion

An ESD workshop *Geelong revisited: from ESD to EBFM – future directions for fisheries management* was held at Melbourne in May 2008. The objectives of the workshop were to review progress of ESD implementation and outcomes of the FRDC ESD subprogram; and determine whether a national program was required for implementing EBFM. There was general agreement that significant progress had been made in the implementation of ESD. Having to undertake fisheries strategic assessments to meet the EPBC Act requirements had played an important role in this progress. There was still a lack of understanding by the community about the level of progress that had been made in the fishing industry. Most of the progress had been made in the ecological areas with minimal progress in social and economic areas. Although tools were now available, there had been inconsistent use of these tools across jurisdictions. It was agreed that the projects and processes which had been undertaken through the ESD subprogram had, overall, been successful. The analysis of the progress which had been made towards ESD based assessment and management of individual fisheries, determined target species were relatively well covered; for non-target species many of the tools used for target species could be applied, however there was less data, but risk assessments could assist with such deficiencies; and the assessment of ecosystem level issues still required further tool development. The economic considerations were not widely used, even though tools are available. For the social and culture areas there was a lack of a clear policy framework. There were few tools available to enable integration of the three ESD components to compare management options and assist with decision-making (Millington and Fletcher, 2008 pp. 3-6).

The other objective was to determine whether a national program was required to assist with the future initiatives of fisheries and marine management. To facilitate this, group discussions were based on three main questions:

- what were the likely future (5-10 years) drivers?
- what were the possible actions to address these drivers? and
- to what degree such actions would be assisted by being co-ordinated through national programs?

The groups provided comments on the benefits from taking a national approach and possible structures and actions, and were these would be relevant. The Australian Fisheries Management Forum was to consider policy options and longer term actions based on the outcomes from the workshop (Millington and Fletcher, 2008 pp. 6-12).

As Fletcher (2009) outlines the second stage of the operation of the ESD subprogram was a period of consolidation rather than generation of new tools. This was considered necessary as it takes time to adopt and integrate significant changes to the methods of operation of agencies and industry. The activities undertaken have provided a basis to demonstrate whether management has credibility in meeting resource sustainability as part of the strategic fisheries assessments requirements under the EPBC act. The tools and process developed within the ESD subprogram have also been applied in other domestic and international systems.

As previously discussed, the implementation of ESD and EBFM has been an incremental and an evolving process for fisheries management in Australia. Although many of the key aspects and elements that underpin ESD and EBFM are in place, implementation is one of degree from conceptual and theoretical underpinnings, towards a fully integrated and comprehensive system; however, much has been achieved in the last ten years, as outlined in table 7.6 below. This is based on a qualitative review which demonstrates the major shifts and developments towards EBFM between 1998 and 2008 (√=planned; √√= partly implemented; √√√=more fully implemented).

Table 7.6: Progress towards ESD and EBFM implementation

Implementation	1998	2008	Remarks
Management policy			
Ecologically Sustainable Development	√	√√	The environmental dimension is considered, more recently (2 yrs) some aspects of the economic dimension considered, the social dimension although considered important is the least developed.
Ecosystem Based Fisheries Management	X	√√	A focus on the wider environmental and conservation components, but not the economic and social dimensions.
EPBC Act and fisheries strategic assessments	X	√√√	Species (target, discards, bycatch and TEPs) most developed in terms of understanding and operational processes and measures for managing impacts; followed by habitats and ecosystems; a focus on MPAs as way of managing fisheries and other cross sectoral issues and impacts.
Management arrangements			
Management plan and regulations	√	√√√	An accredited management plan required as part of fisheries strategic assessments. Supplemented by formal annual arrangements, notices, guides and regulations.
Co-management	√√	√√	A consultative form of co-management has been a feature of Australian operational fisheries management for last 10 yrs. More recently (2yrs) there has been an interest in exploring a move towards a more delegated model of management decision-making.
Compliance	√√√	√√√	An important feature of fisheries management , but more recently a focus on outcome based performance.
Fishers reporting logbooks	√√	√√√	A statutory requirement, and more recently (5yrs) required to include information on non target species and interactions with TEPs.
Management processes and measures			
Effort controls	√√√	√√√	Important management measure, but not always effective in managing effort creep.
Output measures	√√	√√√	More recently a focus on ITQs.
Technical measures	√	√√	Industry gear modifications for mitigating for example bycatch species.
Harvest strategy	X	√√	Recent initiative (last 5 yrs) based on B_{mey} and decision rules, aim to minimise potential for overfishing, and allow rebuilding of stocks where overfished in Commonwealth fisheries.

Table 7.6 continued: Progress towards ESD and EBFM implementation

Implementation	1998	2008	Remarks
Stock assessments	√√	√√√	Previously a more ad hoc approach and difficulties for stocks with poor data. More recently (5 yrs) tools developed for data poor fisheries. Current focus understanding trends in stock status and in setting TACs, which form part of harvest strategies. However, there are still many stocks with no assessment or stocks assessments which are classed as uncertain.
Bycatch and discards	√	√√√	Explicitly considered, but implementation varies across fisheries in terms of extent and impact. Bycatch and discard plans some with formal reporting requirements on implementation of actions Many mitigation measures such as TEDs, SLEDs, bird TAPs are now mandatory in fisheries where bycatch is an issue.
Spatial and temporal management	√	√√√	Fisheries are managed spatially. Spatial and temporal measures have a long history in fisheries. More recently an intentional use of spatial and temporal measures to deal with particular species issues or interactions and environmental sustainability issues. However, not an integrated approach fisheries measures separate to coastal zone measures, and MPA declarations.
Fishery and management assessments			
Strategic assessments under EPBC Act	X	√√√	First round of strategic assessments completed (submissions varied), second round assessments commenced (2005 aim to standardise submission). 2007 amendments to process under EPBC Act 2007 (aim to refine approach).
Management Strategy Evaluation	√	√√	Previously used for considering management options for target species of commercial fisheries. More recently (5yrs) wider environmental requirements included in selected fisheries. Models under development to also include the economic and social dimensions.
ESD assessment	X	√√	National framework developed for commercial fisheries and aquaculture (includes a risk assessment). Used by DoF, but not AFMA. Uptake in other states varies.
Ecological Risk Assessment	X	√√	A number of approaches, ERAF developed for Commonwealth fisheries, National ESD framework used by DoF Uptake in other states varies some have developed own approach or use independent consultants
Marine Stewardship Council (MSC) accreditation	X	√	The West coast rock lobster fishery; Austral Fisheries Pty Ltd. Mackerel Icefish fishery; and the South Australian Lakes and Coorong fishery.
Research and data	√√	√√√	Research and data underpin institutional initiatives and fisheries management arrangements and measures and is crucial for informed decision-making.

Toolbox development

An important point raised during discussions at the *Workshop on toolbox for applying the Ecosystem Approach to fisheries* was that implementation of EBFM requires both the use of existing fisheries management measures and a welldesigned toolbox (FAO, 2009b). In Australia prior to the introduction of ESD and EBFM, there were a number of existing strategic and operational management methods and tools (such as input/output/technical and spatial and temporal measures) already in use by fisheries management agencies. In response to the adoption and introduction of ESD and EBFM, these have been further developed.

As outlined in the 1998 ESD review, with regard to fisheries it was recognised that there was a need for the development of practical methods, processes and tools to enable the Commonwealth and state fisheries agencies to meet ESD objectives and requirements under their respective legislation, and be able to demonstrate these objectives were being met (Sainsbury, Smith and Webb 1998). One of the benefits of the ESD subprogram has been the co-ordination and facilitation of the development of ESD related tools and processes (Fletcher, 2009). As identified in the 2008 ESD and EBFM review a range of assessment and management tools have been developed that support implementation of ESD and EBFM. These include risk based frameworks and methods; qualitative and quantitative fishery assessments; harvest strategies; and, reporting and assessment frameworks. The development of indicators and modelling has also been an important factor in moving towards the implementation of EBFM.

As previously discussed indicators and reference points can be used to define performance measures to track how well management objectives are being achieved, with decision rules to determine adaptive management strategies in response to outcomes from management actions. The findings from the 1988 ESD review (Sainsbury, Smith and Webb, 1998) regarding indicators highlighted the need to develop guidelines for using sustainability indicators, and develop and test options for sustainability indicators. These included the environmental, economic and social indicators. Since then best practice reference points have been developed for ecosystem components (Sainsbury, 2008). The 2008 ESD and EBFM review (Webb and Smith, 2008) highlighted the progress made in developing environmental indicators but identified the need for further development particularly for economic and social indicators. Over the past decade, the nature of the debate on sustainability indicators has undergone a shift (Potts, 2006). Initially debate was centred on the application and identification of frameworks and indicators, and the justification of their use. A new focus is now emerging regarding the use of indicators in decision-making in how indicators are interpreted in terms of objectives and performance measures; how they are communicated; and how they are incorporated into the management system. This shift recognises that the indicator system is not only for reporting, but also for changing management practices.

Models (qualitative or quantitative) are a key tool for integrating a wide range of system information within a common framework. Attempts to model exploited marine ecosystems can: help understanding of system dynamics; identify processes, drivers and responses; highlight major gaps in knowledge; and road test management strategies prior to implementation. An example of the use of modelling in Australia was a component of the North West Shelf Joint Environmental Management Study (NWSJEMS) which developed a new modelling framework for evaluating the effectiveness of strategies for managing major sectors operating on the North West Shelf of Western Australia. This required representation of the ecosystem, the human sectors, and a simulated monitoring and management decision process. The framework was used to evaluate management strategies under various scenarios, taking into account known uncertainties, so as to identify strategies that could robustly meet management objectives. While the track record of MSE in single sector management is now quite extensive, NWSJEMS represented the first attempt to apply the approach across multiple sectors. The key sectors represented in the MSE modelling were: the oil and gas industry including exploration, extraction, processing, and transportation; coastal development including power generation, port facilities, iron ore production and transport, and salt production; fisheries including commercial prawn trawling, fish trawling and trapping, and recreational fishing; and conservation related activities including zoning and other measures to protect key species and habitats. Considering all of these sectors within a single simulation framework allowed for investigation of both cumulative impacts and the potential benefits of co-ordinated monitoring and management across sectors (North West Shelf Joint Environmental Management Study, 2007 pp. 2, 26).

In Australia, over the last decade, the Atlantis framework and approach has been an important tool used by managers for natural resource management decision-making. During this time it has been modified to better handle uncertainty and applied to questions of climate impacts, effective system-level monitoring schemes, and delineating system-level thresholds. An improved understanding of marine systems; increased computer capacity; and a holistic approach to natural resource management have contributed to the development and use of end-to-end ecosystem models. This modelling approach differs from earlier models as it attempt to provide a coupled dynamic representation of the entire system and its major environmental and anthropogenic drivers. The Atlantis modelling framework is one end-to-end model being used to support marine ecosystem-based management and systems understanding intended for use in management strategy evaluation studies. From the inception of Atlantis cumulative impacts have been an important consideration. Currently there are 13 Atlantis models in use in Australia and internationally, with several others under development. Scientifically, the focus on future Atlantis developments in two directions, one expanding the potential end-to-end scope of the model and the questions it can explore; and two, further research into the details of practical EBM and system understanding (Fulton et al., 2010 in press).

As discussed by Smith et al. (2007) moves towards EBFM have evolved during the past decade. This has been driven by a number of policy directions and initiatives, and more recently the adoption of EBFM as a whole of government approach to fisheries management. Initially policy was ahead of the development of knowledge and tools to support implementation. Many of the tools developed were an extension of tools already in use in fisheries assessment and management. The authors consider it helpful to think of the various tools as supporting different elements in the adaptive management cycle (monitoring, assessment and decision-making) that characterise fisheries management, and evaluation of the entire management cycle. ESD and EBFM have broadened the scope of fisheries management concerns, and different tools have been developed, and others may still need to be developed to support management and decision-making. The tools may use qualitative to quantitative methods, and can be based on expert judgement, empirical studies, or quantitative models. The scope, methods and tools can also be considered as framework, that can suggest which elements of the various separate tools may be combined, and to identify missing tools. As the authors point out little attention has been paid to assessment tools that deal with socio-economic considerations, although some of the tools have the capacity to do so, or can be developed to include these elements. As with the EBFM approach, these tools and others being developed or extended, continue to evolve as they are tested in real fisheries.

7.7 Summary

The governance arrangements as discussed in Chapter 6 set the parameters for Commonwealth and state managed fisheries. In this Chapter the systems model (as developed in Chapters 3, 4 and 5) was applied to investigate the management of Australian Commonwealth and state and territory fisheries at the national level, under ESD and EBFM principles. A profile of Australian fisheries and their environmental, economic and social context at the national level was compiled. How ESD and EBFM requirements (as discussed in Chapter 6) and key considerations have been incorporated into fisheries management arrangements, by Commonwealth and state and territory fisheries management agencies was examined and reviewed.

In Australia the fisheries sectors are diverse in terms of the geographical distribution of exploited species; the different methods and types of gear deployed; and the different management regimes under which they operate. Species production is subject to natural variability which affects annual catch rates and in some cases fishing effort. Although Australia's commercial wild caught fisheries and aquaculture sectors are small compared to other countries, they are a valuable export product and also provide the domestic market with seafood products. Australian exports have to compete in world markets where export prices are set by international markets, which dictate prices received by Australian fishers. Nationally fishers can also be affected by variable operational costs, for example diesel fuel and labour costs. All of the fishery sectors are important socially in terms of employment opportunities, with many small coastal communities dependent upon the commercial and the aquaculture sectors. Recreational fishing is an important leisure activity for many Australians, and the fisheries charter sector attracts domestic and overseas visitors, both contribute in terms of infrastructure development and economically (revenue) within the regional areas in which they occur. The continuation of customary traditions and fishing rights are acknowledged as important to Indigenous fishers. A current issue for fisheries management is in regard to resource sharing and allocation between the commercial and recreational fishing, and Indigenous sectors, and within these sectors. In Australia, as elsewhere, climate change is an emerging issue, which will have wide ranging ramifications for the marine environment, and the environmental, economic and social dimensions as they relate to fisheries, and it will be a challenge for fisheries management in developing an adaptive response.

The purpose of this Chapter was to profile Australian fisheries and outline the environmental, economic and social issues and context for Commonwealth and state managed fisheries. To introduce the strategic and operational management approaches adopted by Australia under ESD and EBFM principles, and the methods and tools developed for use by Commonwealth and state and territory fishery agencies. Application of these approaches, methods and tools by fisheries management were reviewed in 1998 (Sainsbury, Smith and Webb, 1998) and 2008 (Webb and Smith, 2008) as discussed above. Outcomes from the reviews and discussions in this Chapter suggest that initially policy was ahead of the tools needed for implementation. Since 1998 existing fisheries tools have been further extended and new tools and methods have been developed to support the implementation of EBFM, and in response to fisheries issues. These now form part of the fisheries strategic and operational management cycle and provide a toolbox of methods and tools available, to be used by fisheries management agencies. One clear lesson has emerged: no one method or tool is capable of managing fisheries, it requires a range of approaches which can be tailored to the particular fishery circumstances and context. Within the past ten years much has been achieved to support fisheries management in its transition towards the implementation of EBFM. However, as outlined in the reviews, the uptake of these methods and tools varies within and between fisheries and across management jurisdictions. These outcomes point to the need for further work to identify the reasons for these differences; the need to fully integrate the environmental, economic and social dimensions into fisheries management; the need for effective feedback loops within the fishery and management systems to facilitate learning; and robust methods that are able to evaluate management actions and performance outcomes. The implementation of these strategic and operational fishery approaches, methods and tools will be further illustrated in detail by two case studies a Commonwealth fishery managed by AFMA, the Southern and Eastern Scalefish and Shark Fishery (SESSF); and a Western Australian fishery managed by the Department of Fisheries, the West Coast Rock Lobster Fishery (WCRLF) and is the focus of Chapter 8.

CHAPTER 8: IMPLEMENTATION OF ESD AND EBFM IN AUSTRALIAN FISHERIES: TWO CASE STUDIES

8.1 Introduction

Cunningham (2005a) argues that while there are problems and pessimism regarding fisheries management there is also reason for optimism as there are examples of well managed fisheries. As Bostock (2005) highlighted what is meant by success will differ according to the specific management and policy objectives and fishery conditions, and that success cannot be achieved by focusing on one factor. Success in fisheries management is multi-dimensional in terms of meeting biological, economic, and social objectives. It requires institutional capacity to define an appropriate balance of these parameters within management objectives; to implement and adapt these responsively over time; and the management system must also be anticipatory in relation to changing conditions. Brady and Waldo (2009) note that fisheries are complex environmental, economic and social systems and the resolution of fishery issues requires a multi-disciplinary approach.

There are methods that provide solutions for specific problems, but often these are championed as a single panacea or solution without due consideration of the fishery as a whole. This may result in outcomes where one problem is solved but may cause other problems elsewhere in the system. The approaches, methods and solutions from different disciplines (ecologists, economists and sociologists) while well suited to solve a particular problem in a fishery do not solve them all. Different approaches could be complementary, but the question is to what extent solutions from these different disciplines might be successfully integrated and how (Brady and Waldo, 2009). While there is no single approach to successful fisheries management (management arrangements need to be tailored to the particular circumstances of the fishery), there are factors that facilitate success (Cunningham, 2005b). These include creating appropriate incentives that improve exploitation patterns and compliance with regulations; developing institutional capacity; and taking a holistic approach to fisheries management planning. The development of co-operative and participatory mechanism between fishers (horizontal) and between fishers, industry, management and the state (vertical) is important, and this may be achieved though co-management arrangements.

Fishery systems are dynamic and management needs to reassess and adapt management arrangements as necessary (Cunningham, 2005b). Although Australia also faces many challenges in managing its fisheries resources, generally Australian fisheries have a reputation of being well managed.

In this Chapter the systems model will be applied to identify how Ecologically sustainable Development (ESD) and Ecosystem Based Fisheries Management (EBFM) principles and requirements (as discussed in Chapter 7) have been incorporated into the strategic management arrangements at the fishery agency level, and how these have been implemented into operational management at the individual fishery level, through two case studies. The systems approach and integrated model as presented in Chapter 5 will be applied as it relates to the strategic and operational fisheries management for Australia's fisheries agencies and two case study fisheries. The Southern and Eastern Scalefish and Shark Fishery (SESSF), a Commonwealth fishery, managed by the Australian Fisheries Management Authority (AFMA); and the West Coast Rock Lobster Fishery (WCRLF) managed by the WA the Department of Fisheries (DoF). These case studies allow the comparison of a multi-species, multi-gear and multi-sector fishery (SESSF); and a single species and single method fishery (WCRLF).

8.2 Commonwealth fisheries

A brief overview of Commonwealth managed fisheries and recent management changes for the Australian Fisheries Management Authority, will be presented as background and introduction to the case study fishery the SESSF.

8.2.1 Biological and economic status of Commonwealth fisheries

The Bureau of Rural Science (BRS) in the annual *Fishery Status Reports* provides an independent assessment of the status of fish stocks for commercial Commonwealth managed fisheries, and reports on trends that may affect the fishing industry, fisheries management and the broader community. For the period 1992 to 2005 the status reports highlighted a trend of a continued, and increasing number of stocks that were considered over-fished, or subject to over-fishing, as well as a large number of stocks for which the status was uncertain (Larcombe and Begg, 2008 pp. v, 7). It should be noted that since 1992, the number of stocks assessed has increased, from 31 in 1992 to

98 in 2008. Under the new biological classification method introduced in 2004 the biological status of assessed stocks for 2008 were over-fished status (not over-fished 44; over-fished 13; uncertain if over-fished 41) and over-fishing status (not subject to over-fishing 57; subject to over-fishing 8; uncertain if over-fishing 33). In 2008 from a biological perspective, of the 98 stocks assessed, the number of stocks classed as uncertain was still a matter of concern. In response, the Australian Government funded a three year research project (BRS in collaboration with Commonwealth Science and Industrial Research Organisation (CSIRO)) “Reducing Uncertainty in Stock Status”, which commenced in 2008/09. The two main aims/directions are a framework for determining stock status; and harvest strategy testing, evaluation and development (Wilson et al., 2009 pp. 4-12).

AFMA manages more than 20 fisheries, and the Commonwealth wild caught fisheries accounted for 13% of the gross value of production of Australian fisheries and aquaculture in 2006/2007, and 2007/2008. In 2007/2008 the top five Commonwealth fisheries by value (highest to lowest) were Northern Prawn Fishery (A$74million); SESSF Commonwealth Trawl Sector (A$46 million); Southern Bluefin Tuna (A$45 million); Eastern Tuna and Billfish (A$32 million); and SESSF Gillnet, Hook and Trap sector (A$28 million). In 2007/2008 prawns remained the most valuable Commonwealth species followed by tunas, and sharks; other species included flathead, blue grenadier; rock lobster, broadbill swordfish and ling. The real value of Commonwealth fisheries has fallen by almost 50% from A$582 million in 2000/2001 to A$ 288 million in 2007/2008; production has also declined by 28% from 72,300t. in 2000/2001 to 52,200t. in 2007/2008 (Pham and Peat, 2009 pp. 8, 12-14, 32-33).

The Australian Bureau of Agriculture and Resource Economics (ABARE) has conducted economic surveys of major Commonwealth fisheries since the early 1990s. Major fisheries are defined as those with a gross value production greater than A$4 million and small fisheries as less than A$4 million. Since 2007 ABARE has produced annual *Fishery Economic Status Reports*, and for the first time in 2008 this information was combined into the BRS *Fishery Status Report 2008*. Historically the overall economic performance of some Commonwealth fisheries has been poor (Newton et al., October 2007 pp. 1-2.; Hohnen et al., 2008 p. 8). According to Hohnen et al. (2008 pp.12-19) an economically efficient fishery will have the following three characteristics.

One, total catch and effort are restricted to the point where net economic returns over time are maximised. This prevents rational fishers from expanding their effort until all profits are dissipated. This is known as fishery level efficiency. Two, revenues are maximised and catching costs are minimised for a given quantity of catch. This can be referred to as vessel level efficiency. While fishers can be relied on to choose the combination of inputs which minimise costs and maximise revenue for their particular operation (given the constraints imposed by fisheries management), the management measures used in a fishery can have a significant impact on the costs and revenues of fishing. Three, fisheries management services are provided effectively, at least cost for the given level of management (not necessarily at lowest cost overall), referred to as management efficiency. Assessment of economic efficiency is complex as it requires a comparison between the potential net economic returns available for the fishery and those realised under the prevailing management system, and both are subject to uncertainty. No single indicator or methodology is appropriate for assessing economic performance of all fisheries. The range of indicators used can include net economic returns, productivity indexes, latent effort and value of quota; and tools used may include profit decompositions, stochastic frontier analysis and bio-economic models.

8.2.2 AFMA Commonwealth managed fisheries under ESD and EBFM principles

Under the *Fisheries Management Act 1991* AFMA is responsible for the efficient management and sustainable use of Commonwealth fisheries resources on behalf of the Australian community. AFMA is also required to ensure exploitation of fisheries resources and related activities are conducted in a manner consistent with ESD, and the precautionary principle, in particular, with regard to the impact of fishing activities on non-target species, and the long-term sustainability of the marine environment. Decision-making processes should also integrate both long-term and short-term economic, environmental, social and equity considerations (Australian Fisheries Management Authority, 3 February 2009).

AFMA is undertaking a number of initiatives to implement EBFM across all Commonwealth fisheries with key components being ecological risk management, managing bycatch and interactions with threatened, endangered or protected species (TEPs). As discussed in chapter 7, Commonwealth fisheries are assessed under the

Environment Protection and Biodiversity Conservation Act 1999 to ensure that fisheries are managed in an ecologically sustainable way (Australian Fisheries Management Authority, 2 September 2008).

To address the issues of profitability and sustainability of Commonwealth fisheries, the Australian Government and AFMA introduced policy initiatives, which have changed the strategic and operational management arrangements for commercial Commonwealth managed fisheries. In 1989 the Commonwealth Government released the comprehensive policy statement, *New Directions for Commonwealth Fisheries Management in the 1990s* (Department of Primary Industries and Energy, 1989). The *Looking to the future: a review of Commonwealth Polic*y (Department of Agriculture, Fisheries and Forestry, 2003) highlighted the need for ecosystem based fisheries management. The $220 million *Securing our Fishing Future* package was announced in November 2005, which was designed to deliver profitable and sustainable Commonwealth fisheries for the future. The package included three features: AFMA was to introduce new fisheries management actions to ensure Commonwealth managed fisheries remain sustainable; a proposed network of Marine Protected Areas (MPAs) in the South-east Marine Region; and a fisheries structural adjustment package (Department of Agriculture, Fisheries and Forestry, 26 October 2009).

Minister's Statutory Direction (2005)

In support of *Looking to the future: a review of Commonwealth Polic*y and as part of *Securing our Fishing Future Package* the Minister for Australian Fisheries and Conservation issued AFMA with a statutory Direction on 16 December 2005 (Commonwealth of Australia, Gazetted 20 December 2005) to implement a range of measures to halt over-fishing and to create the conditions that would give over-fished stocks a chance to recover to an acceptable level in the near future. Actions to achieve this under section 91 of the *Fisheries Management Act 1991* included:

- taking immediate action to cease over-fishing and recover over-fished stocks to a level that would ensure long-term sustainability and productivity;
- avoid further species from becoming over-fished in the short and long-term; and

- manage the broader environmental impacts of fishing, including threatened species or those otherwise protected under the EPBC Act.

AFMA was to take a more strategic, science based approach to setting total allowable catch and/or effort levels consistent with a world's best practice Harvest Strategy Policy. AFMA was to implement harvest strategies (consistent with the Commonwealth Harvest Strategy Policy), in all Commonwealth fisheries. It was also to implement the government policy of managing Commonwealth fisheries using output controls in the form of individual transferable quotas (ITQs), unless it was not cost effective, or was otherwise detrimental to the fishery. Other actions included determining whether boat permits and/or boat Statutory Fishing Rights (SFRs) were an impediment to autonomous adjustment; minimising incentives for discarding by ensuring these were factored into total allowable catch (TACs); establishing a system of independent surveys to increase the transparency and integrity of catch and effort information; and enhance monitoring of fishing activity. AFMA was to provide reports to the Minister, outlining how AFMA was implementing the Direction, and from 2006-2010, outline progress on implementation of the Direction in its Annual Report to parliament (Commonwealth of Australia, Gazetted 20 December 2005).

AFMA's response to the Ministerial Direction (2006)

In response to the Australian Government's direction, AFMA outlined the new management arrangements that would be implemented in Commonwealth managed fisheries in the document *Future operating environment for Commonwealth fisheries* (Australian Fisheries Management Authority, 28 February 2006). AFMA committed to implement the following measures:

- *Sustainable stocks:* a new Harvest Strategy Framework would be applied to all Commonwealth managed fisheries by 2008. The framework sets the goalposts for managing catches by setting agreed target and limit reference points and clear decision rules for each species.
- *Managing risk:* Ecological Risk Assessments (ERAs) identify the risks that fishing posed to the ecological sustainability of the marine environment and helps prioritise management needs. ERAs were to be completed for all

Commonwealth fisheries during 2006. Many of AFMAs future fisheries management decisions would be based on the outcomes of the ERA process.

- *Improved compliance and data:* to improve compliance and data and minimise management costs, the following actions were to be introduced into Commonwealth fisheries. Vessel Monitoring Systems (VMS) would become compulsory in all Commonwealth fisheries; on-board catch-monitoring cameras would be increasingly used to complement existing observer programs; an electronic licensing transaction system was to be developed; administrative rather than prosecution based penalties were to be used more frequently for fisheries offences; measures designed to minimise the black market in illegally caught fish; and measures to protect threatened, vulnerable or endangered species would be enhanced and further developed where necessary.
- *Reducing discarding and bycatch:* discarding of species subject to a total allowable catch limit, or quota management, would be illegal in all Commonwealth fisheries by 2007. Assess and implement measures to significantly reduce bycatch in all Commonwealth fisheries, with the goal to halve it by 2008.
- *Efficient management arrangements:* AFMA supported the negotiation of new Offshore Constitutional Settlement arrangements being developed by the Australian Government with the states and Northern Territory. AFMA would also begin the process of reviewing those fisheries not under ITQ management during 2006.
- *Specific fishery actions:* AFMA would undertake specific fishery actions for the Southern and Eastern Scalefish and Shark Fishery, Eastern Tuna and Billfish Fishery, and the Bass Strait Central Zone Scallop Fishery (Australian Fisheries Management Authority, 28 February 2006).

AFMA has reported progress against these actions as required by the Ministerial Direction in AFMAs annual reports to parliament. The Corporate Plan 2009-2014 sets out AFMA’s principal goals and broad strategies, which is supported by an annual operation plan (Australian Fisheries Management Authority, 4 February 2010). AFMA establishes research priorities for Commonwealth fisheries and arranges for research to be undertaken to address these. AFMA’s current strategic research plan is for the period 2005-2010 (Australian Fisheries Management Authority, 2005).

8.3 The Southern and Eastern Scalefish and Shark Fisheries: a case study

In this section a brief background to the SESSF, the biosocioeconomic context of the fishery and current management arrangements will be outlined.

8.3.1 Background and overview

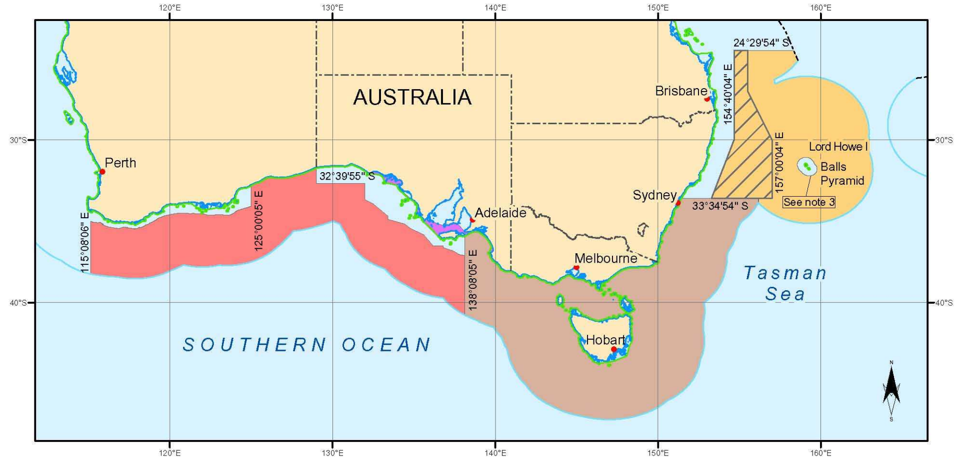
The creation of the Southern and Eastern Scalefish and Shark Fishery (SESSF) in 2003 was to provide AFMA with a platform to improve management of the previously independently managed sectors of the fishery by moving towards a more ecosystem-based approach, by managing the sectors under common goals and objectives. The SESSF has four component sectors:

- The Commonwealth trawl sector (replaces the South East Trawl Fishery, and the Commonwealth Victorian coastal waters sector replaces the Commonwealth Victorian Inshore Trawl Fishery).
- The Great Australian Bight trawl sector (formerly the Great Australian Bight Trawl Fishery).
- The Shark gillnet hook and trap sectors (include the scalefish hook, shark hook, gillnet, and the five trap permits issued under the plan are also considered as part of this collective).
- The East Coast Deepwater trawl sector (previously managed as part of the South East Trawl Fishery, the East Coast Deepwater trawl sector) (Australian Fisheries Management Authority, 25 August 2009).

Maps of the SESSF fishery sectors and a brief description of the sectors are provided below.

Southern and Eastern Scalefish and Shark Fishery

Commonwealth Trawl Sectors and South Australian Coastal Waters Sector



LEGEND

- East Coast Deepwater Trawl Sector
- Trawl Exclusion Zone (closed by permit conditions)
- Commonwealth GAB Trawl Sector
- Commonwealth Trawl Sector
- South Australia Coastal Waters Sector
- Limit of Coastal Waters (3nm)
- Limit of Australian Fishing Zone (200nm)

Projection: Geographic
Datum: GDA94

NOTES:
1. The sectors of the fishery are sourced from Schedule 1 of the SESS Management Plan, September 2003.
2. The maritime zone boundaries shown on this map are sourced from AMBIS 2001 (v1.1) (October 2001).
3. The area of the East Coast Deepwater Trawl Sector excludes waters within 25 nautical miles of the coastline of Lord Howe Island and Balls Pyramid at low water.

Australian Government
Australian Fisheries Management Authority

Produced by the National Mapping Division of Geoscience Australia, for the Australian Fisheries Management Authority, April 2005.
MP 03/2457.34.28

Southern and Eastern Scalefish and Shark Fishery

Commonwealth Hook Sectors and Gillnet Sector

LEGEND

- Commonwealth Scalefish Hook Sector
- Commonwealth Gillnet Sector or Commonwealth Shark Hook Sector
- Land and coastline
- Limit of Coastal Waters (3nm)
- Limit of Australian Fishing Zone (200nm)

Projection: Geographic
Datum: GDA94

NOTES:
1. The sectors of the fishery are sourced from Schedule 1 of the SESS Management Plan, September 2003.
2. The maritime zone boundaries shown on this map are sourced from AMBIS 2001 (v1.1) (October 2001).
3. The area of the Scalefish Hook Sector excludes waters within 25 nautical miles of the coastline of Lord Howe Island and Balls Pyramid at low water.

Produced by the National Mapping Division of Geoscience Australia, for the Australian Fisheries Management Authority, April 2005.

MP 03/2457.34.27

Australian Government
Australian Fisheries Management Authority

SESSF sectors

The SESSF is a complex multi-sector, multi-gear, and multi-species fishery targeting scalefish and shark species (Smith and Smith, 2001). The geographical area of the fishery stretches from the south east of Queensland to the south west of Western Australia. The fishery operates in both Commonwealth and state waters under complex jurisdictional arrangements resulting from different Offshore Constitutional Settlement arrangements with state governments (Morison, 2008 p. 103; Morison et al., 2009b p. 106). The SESSF encompasses three bioregional plans (under the EPBC Act) the east, south-east, and south-west plans. Table 8.3.1 for each sector of the SESSF, outlines the fishing methods; main species; fishing permits/active vessels; and management methods for 2007/08.

Table 8.3.1: The SESSF sectors.

Sector	Fishing methods	Main species	Permits/active vessels	Management methods
Commonwealth Trawl and Scale fish hook sectors	Demersal trawl Danish seine Hook methods Trap	Target species: blue grenadier silver warehou flathead pink ling Byproduct: orange roughy and 3 species of gulper shark	CTS 59 boat SFRs and 22 Victorian coastal trawl permits Active vessels 67 (53trawl and 14 non trawl)	Harvest Strategy Framework (Smith et al. 2008) Input controls: limited entry, gear restrictions, area closures Output controls: TACs, ITQs, trip limits, and a minimum size for flathead
Great Australian Bight trawl sector	Demersal trawl There is interest in developing the potential mid-water trawling for small pelagics and Goulds squid	Target species: deepwater flathead Bight redfish	Fishing permits 10 Active vessels 7	Harvest strategy Input controls: limited entry, area closures Output controls: TAC distributed as ITQs for main target species
Shark gillnet and hook sectors	Demersal gillnet Demersal longline	Target species: gummy shark school shark Byproduct species: saw shark, elephant fish, other sharks and finfish	Fishing permits 75 (gillnet 62 and hook 13) Active vessels 62	Harvest strategy Input controls: gear restrictions, closed areas Output controls: ITQs, legal minimum lengths
East Coast Deepwater trawl sector	Demersal trawl Midwater trawl	Target: alfonsino Byproduct: boarfish and orange roughy	1vessel Active vessels 1	Input controls; SFRs (alfonsino) Output controls: TACs (orange roughy and boar fish).

(Morison et al., 2009c pp. 115-116; Patterson and Pham, 2009 p.169; Morison et al., 2009a pp.174-175; McLoughlin and Wood, 2009 pp.187-188)

Fishing fleets

The SESSF fleet is comparatively old with 40% of the fleet over 30 years old, and 80% over 20 years old. The Commonwealth trawl sector fleets (otter trawl and Danish seine) are made up of a number of sub-fleets by geographical operation, and are made of wood or steel, with average lengths ranging from 16 to 22.7 metres in length. The dedicated deepwater fleet comprises vessels that mainly target deepwater species such as orange roughy and blue grenadier and operate vessels made of steel averaging 31.6m length.

Deepwater trawl vessels operate from 5-14 days away from port; other trawl fisheries average one to three days at sea; and gillnet operators average 5-7 days at sea. Vessels other than trawlers generally discharge their catch at their home ports. Long distance fishermen discharge their catch at the port closest to the main fishing grounds. The SESSF has only a moderate level of corporate ownership, the majority of the fleet is owned by family businesses, and employment on the vessels often involves family members. Following the buyout (under the *Securining our fishieries future* outlined below), which resulted in significant numbers of skippers and crew being displaced. The availability of labour has not been an issue, but obtaining skilled skippers is a constraint, and crew turnover remains high due to competition from other employment opportunities (CDI Pinnacle Management Pty Ltd, 18 June 2007 pp. 35-36, 88-89).

Post harvest sector

The primary landing ports for the Commonwealth trawl sector and scalefish hook sectors are Lakes Entrance and Eden; with the main domestic markets being Sydney and Melbourne, catch sold as fresh or frozen products; and to a lesser extent as exports (Morison et al., 2009c p. 115). The primary landing ports for the Great Australian Bight trawl sector are Port Lincoln for the domestic market, catch sold as fresh or frozen products, and as exports to market European markets, sold as frozen products (Morison et al., 2009a p. 174). The primary landing ports for the Shark gillnet and hook sectors are Lakes Entrance, San Remo, Port Welshpool and Devonport, for the Melbourne market, catch sold as fresh or frozen products (McLoughlin and Wood, 2009 p. 187). The primary landing ports for the East Coast Deepwater trawl sector are Brisbane and Eden, for the domestic market sold as frozen and chilled products (Patterson and Pham, 2009 p. 169). There is minimal value adding, and there appears to be limited opportunities for value adding as consumer preference is for fresh chilled fish products. Estimated unit value per kilogram (wholesale price) for the SESSF in 2006 ranged between $1.90 (spotted warehou) to $10.60 (John Dory). Of the other quota species wholesale prices were blue eye travella, gummy shark, and school shark ($9); pink ling ($7); blue grenadier, deepwater flathead and orange roughy ($5) and for the other quota species wholesale prices were below $5 (CDI Pinnacle Management Pty Ltd, 18 June 2007 pp. 5; 31-32).

8.3.2 Environmental, economic and social context

Environment

The status of quota species for each sector of the SESSF as reported in the annual *Fishery Status reports 2008* is outlined in Table 8.3.2. Five classifications of stock status are used:

- not over-fished: refers to the biomass of a fish stock. The biomass is adequate, more technically, the stock has a biomass above the limit reference point ($B_{LIM});$
- over-fished: refers to the biomass of a fish stock. There are too few left, more technically, the stock has biomass below the limit reference point;
- not subject to over-fishing: refers to the amount of fishing. The stock is not undergoing too much fishing, that is, the exploitation rate does not exceed the fishing mortality limit reference point;
- subject to over-fishing: refers to the amount of fishing. The stock is undergoing too much fishing, that is, the amount of fishing exceeds the fishing mortality limit referent point; and
- uncertain: refers to the over-fished or over-fishing status of a fish stock for which there is inadequate information (Larcombe and Begg, 2008 pp. 3-4).

Table 8.3.2(a): SESSF sectors and stock status for 2008.

Sector	Not overfished/ not subject to overfishing	Overfished/subject to overfishing	Uncertain
Commonwealth trawl and Scalefish-hook sectors	Blue-eye trevalla; blue grenadier; Deepwater sharks (eastern 18 sp., western 18sp.); eastern school whiting; flathead (5 sp.); mirror dory; ocean perch; orange roughy (Cascade Plateau); ribaldo; royal red prawn; silver trevally; silver warehou.	Blue warehou; eastern gemfish; gulper sharks (upper slope); jackass morwong; john dory; orange roughy (eastern , southern and western zones); smooth oreo dory (Cascade Plateau stock) other oreo dories (4 sp.); pink ling;	western gemfish; redfish
Great Australian Bight trawl sector	bight redfish; deepwater flathead		orange roughy
Shark gillnet and hook sectors	gummy shark (current gummy shark catches were considered sustainable, but recent assessments indicate a slow decline of pup numbers since the 1980s)	school shark	sawshark and elephant fish
East cost deepwater trawl			Alfonsio

(Morison et al., 2009c pp. 113-114; Patterson and Pham, 2009 p.168; Morison et al., 2009a p.174; McLoughlin and Wood, 2009 p.187)

For the Commonwealth trawl and scalefish-hook sectors three stocks have been newly classified as either over-fished and/or subject to over-fishing in 2008, these awee the blue warehou, upper-slope gulper sharks and jackass morwong (Morison et al., 2009c p. 113). Table 8.3.2(b) outlines some of the bycatch and habitat issues within the SESSF sectors.

Table 8.3.2(b): SESSF sectors bycatch and habitat issues 2008.

Sector	Bycatch	Habitats
Commonwealth Trawl and Scalefish-hook	Significant level of general bycatch in trawl sectors. 2004 ISMP data indicated 30% by weight of catch of non-quota species in CTS and 9% in the hook sector. The CTS is known to interact with the Australian fur seal. Interactions with the hook sector are much fewer. There have been rare interactions with two protected shark species (great white and grey nurse sharks) in the CTs and ScHs sectors. Sygnathids are taken as bycatch and ISMP data suggest Danish seining has the greatest potential for interaction, as they operate in shallower water and use a small mesh size. Catches were recorded for 2000-2002, but none for 2007 or 2008, decrease thought to be associated with under reporting.	The potential for damage to marine benthos from demersal trawling is of concern (lack regulations re size of footrope gear). Available spatial distribution of trawl effort indicates mostly confined to established historical fishing ground
Great Australian Bight trawl	On board observer program reported modest discarding of commercial species, but substantial discarding (44% by weight of the overall catch) of non-commercial species in the continental-shelf. Latchet, for which there is currently only a small market, are discarded in large numbers. Seabirds are known to interact with fishing activities particularly longlining and trawls. No bycatch of marine mammals or seabirds were reported by onboard observers. There is interest in developing mid-water trawling for small pelagics and Goulds squid, if commercial operations start bycatch will need to be monitored.	Most shelf trawls are on soft, sandy substrates with little sessile fauna or flora, but some exploratory shots near established grounds contained substantial benthos.

Sector	Bycatch	Habitats
Shark gillnet and hook	Most discards (notably draughtboard and Port Jackson sharks, and piked spurdog) are released live. With 3% of commercial chondrichthyan catch and 2% of scalefish catch discarded dead. There is concern regarding interactions with Australian sea lions	
East cost deepwater trawl	Nothing reported for 2008	Nothing reported for 2008

(Morison et al., 2009c pp. 162-165; Patterson and Pham, 2009 p.172; Morison et al., 2009a p.183-184; McLoughlin and Wood, 2009 p.199)

Global climate models predict that the greatest sea surface temperature warming in the Southern hemisphere oceans will be off south-eastern Australia due to the likely effect of a poleward shift in zonal winds. The SESSF fishery overlaps this area. Biological impacts are likely to be substantial in this region and according to Hobday et al. (2008) may be the most pronounced of any marine region in Australia for two reasons. First, strong recruitment of many species in the region depends upon the persistent zonal west winds, which are likely to be weakened due to the predicted poleward shift in zonal winds, leading to poor recruitment of fished and non-fished species. Second, the predicted sea surface warming is likely to effect the distribution of many species, and as a result changes to community competition and ecosystem function. Although there is a long history of fishing in this region, the effects of climate change on marine stocks and fisheries have not been well studied. Ecosystems and fisheries impacts of these changes are already occurring. These changes on biota could effect fisheries management in terms of harvest strategies as defined in the Commonwealth Harvest Strategy Policy; and with respect to access and property rights as species distributions change.

The report *Impacts of Climate Change on Australian Marine Life* focused on different aspects of vulnerability. One emphasised the geographic areas that may be most at risk, and the other focused on the most vulnerable marine groups. The domains considered most vulnerable were those in the Eastern Central and South eastern domains. The most affected marine groups are likely to be tropical coral reefs; cold water coral reefs; rocky reefs and kelps; phytoplankton and zooplankton; and benthic and demersal fish. The largest climate impacts are expected to be on biological communities more generally, because the marine organisms that are likely to be highly impacted are foundation species, or species that form the base of the open ocean food-web (Hobday et al., September 2006a pp. 6-11; Hobday et al., September 2006b pp. 6-12). AFMA is aware of climate change factors, and although not currently developing specific actions, continues to monitor research into the effects of climate change (Australian Fisheries Management Authority, 2009 p. 3).

Economic

The SESSF is one of the most economically valuable Commonwealth managed fisheries, with a Gross Value Production (GVP) of $86.7 million in 2007-2008 (13% down on 2006/2007), accounting for 30% of the GVP of Commonwealth fisheries for 2007/08. The Commonwealth trawl and scalefish hook sectors contributed A$53.9 million (17% down on 2006/2007); the Great Australian Bight trawl sector A$12.8 million (31% down on 2006/2007); the shark gillnet and shark hook sectors A$20.0 million (up 27% on 2006/2007); and for East Coast Deepwater Trawl sector this information is confidential as there are less than five vessels operating in the fishery (Wilson et al., 2009 pp. 26-29). By sector, the Commonwealth trawl sector is the most important by volume followed by the Great Australian Bight trawl sector. The shark gillnet and shark hook sectors while considerably smaller in volume has a significantly higher unit value of catch, and remains an important component of the SESSF fishery (Wilson et al., 2009 pp. 26-29, 107; CDI Pinnacle Management Pty Ltd, 18 June 2007 pp. 30, 37).

Factors outside the control of the fishery, that influence both net economic returns and other measures of financial performance in the fishery, include the movement of the Australian dollar against other major currencies, labour costs, and fuel prices (Newton et al., October 2007 p. 24). The ABARE *Fishery economic status report 2007* indicated that net economic returns for the Commonwealth trawl sector were low given the size of the sector. The highest estimate for the past 10 years (equivalent to 2007-2008 dollars) was $5.9 million recorded in 1997-1998. More recently, net economic returns were negative between 2002-2003 and 2004-2005 before becoming positive, rising to $1.5million in 2005-2006, and $3.5million in 2006-2007. Of total cash costs, labour represented 29%; fuel 22%; freight and marketing 19%; and repairs and maintenance 11%. Relative to the Commonwealth trawl sector, the gillnet, hook and trap sector, has generally been more profitable. Since 1998-99 net economic returns have averaged \$1.3million (equivalent to 2007-2008 dollars). In 2006-2007 net economic returns were \$1.5million. Of total cash costs, labour represented 40%; fuel 10%; freight and marketing 4%; and repairs and maintenance 14% (Hohnen et al., 2008 pp. 78-81). In the Great Australian Bight trawl sector a high level of latent effort in the fishery is indicative of low profitability, and net economic returns of the fishery are likely to be low. As a trawl fishery it is particularly susceptible to rises in fuel prices, as was experienced in 2007/08, which are likely to have affected profitability. Higher prices for key species caught in the fishery for 2009, indicates that profitability may have improved for the 2008/2009 year (Morison et al., 2009a p. 183). For the East coast deepwater trawl sector no economic surveys have been conducted. Given the low level of fishing effort and catch in 2007/2008 and recent years, it is unlikely that profits in the fishery are significant (Patterson and Pham, 2009 p. 171).

Social

In general, fishers are optimistic about the future of the SESSF, as fishing effort has been removed as a result of the structural adjustment (CDI Pinnacle Management Pty Ltd, 18 June 2007 p. 1). The results of the buyout were seen as positive by the majority of the fishing communities with the exception of a number of towns (Wollongong, Bermagui, Ulladulla and Eden) in southern NSW, which have lost the majority of their fishing fleet. There are no definitive estimates of employment generated by the SESSF as direct and indirect labour impacts are difficult to estimate due to the extended nature of the fishery; the casual nature of the workforce and high staff turnovers; and employment information is not captured at the individual fishery level by the Australian Bureau of Statistics. CDI Pinnacle Management Pty. Ltd. estimated employment in the SESSF based on the total number of vessels active in the fishery; the average crew numbers per vessel on a full-time equivalent basis; and survey data to estimate packing/processing labour. On this basis for 2007 the total employment in direct fishing was estimated at 304 persons (otter trawl 116, Danish seine 33, GHAT 155); 60-120 administrative and management persons related to the direct operation of the fishing business; and the best estimate of employment created in the post harvest sector, by the fishery is 354 persons (CDI Pinnacle Management Pty Ltd, 18 June 2007 pp. 86-88).

8.3.3 Management of the SESSF

A summary of the current operational management arrangements for the SESSF is given in table 8.3.3.

Table 8.3.3: Summary of current operational management for the SESSF.

Summary of management for the SESSF	
Legislation	
Commonwealth Legislation	Offshore Constitutional Settlement (OCS) *Fisheries Administration Act 1991* *Fisheries (Administration) Regulations 1992* *Fisheries Management Act 1991* *Fisheries Management Regulations 1992* *Environment Protection and Biodiversity Conservation Act 1999*
Consultation and stakeholder participation	
Stakeholders, forums and mechanisms	Joint Management Advisory Committee meetings for the Southern and Eastern Scalefish and Shark Fishery. South East MAC; and GABMAC. SlopeRAG; ShelfRAG; DeepRAG; SharkRAG; GABRAG. Port visits. Industry associations SETFIA, SEFA , GABIA.
Co-management arrangements interest in a more delegated approach	The project Co-management for Commonwealth fisheries (AFMA 2008). Certain aspects of delegated co-management arrangements are being trialled in the Great Australian Bight Trawl Fishery (GABTF).

Table 8.3.3 continued: Summary of current operational management for the SESSF.

Summary of management for the SESSF	
Management arrangements	
Management plan and regulations	Southern and Eastern Scalefish and Shark Fishery Management Plan 2003 as amended as 15 January 2007 and accredited under the EPBC Act. Guide to the 2009 SESSF management arrangements. Guide to the 2009 GAB management arrangements.
Industry code of practice and conduct	South East trawl fishery industry code of conduct for responsible fishing 1995. Code of Fishing Practice to Minimise Incidental Bycatch of Marine Mammals in the South East Trawl Fishery 1999 and 2007.
Structural adjustments	*Securing our fishing future* (Department Agriculture, Fisheries and Forestry November 2005) structural adjustment for the SESSF in the Commonwealth trawl and scalefish hook and shark gillnet and hook sectors.
Compliance and enforcement	In accordance with the Management plan 2003 and management arrangements 2009. Compliance activities for 2008/09 included at-sea and in-port vessel inspections; fish receiver (processor) inspections; trips/landings inspected. For those Commonwealth fisheries inspected 183 offences were detected of which 128 were in the SESSF (AFMA 2009 p. 41).
Fishers reporting requirements	Fishers daily logbooks provide for the recording of information on the location, time, gear and method of fishing as well as the resultant catch for each fishing operation, and interactions with TEPs.
Management processes and measures	
Inputs/outputs/technical measures	Both input and output controls, ITQs and SFRs quotas, boat SFR types and fishing permits (SESSF management arrangements 2009).
Allocation of user rights	Total allowable catches (TACs) are set for quota and non quota species groups. In most cases these are allocated to fishers as statutory fishing rights (SFRs) and in the form of individual transferable quotas (ITQs) and require a boat SFR or permit.
Stock assessment	Stock assessment in the SESSF sectors, are coordinated by the Southern and Eastern Scalefish and Shark Resource Assessment Group (SESSRAG), previously known as SEFAG.

Table 8.3.3 continued: Summary of current operational management for the SESSF.

Summary of management for the SESSF	
Quotas and TACs	Significant changes between 2003 and 2009, a decrease in the TACs for most species. Global TAC set with estimate of discards now factored into TACs.
Harvest strategies	First applied 2005 and each year since. Initially based on four tiers, refined and now three, with recommended Biological Catch (RBC) as components of the management and TAC setting. Stock rebuilding strategies for Eastern gemfish, School shark, blue warehou, and Orange roughy conservation programme.
Objectives/indicators/decision rules	Target reference point expresses the desired status of stocks (B_{TARG}) and desired fishing intensity. Limit reference points (B_{LIM} and F_{LIM}) express situations to be avoided because they represent a point beyond which the risk to the stock as the basis if a commercial fishery is regarded as unacceptably high (AFMA 2007). For more details see Smith et al. 2008.
Spatial and temporal management	As part of *Securing our fishing future* (2005) and NRSMPA the South-east Commonwealth Marine Reserve Network declared 5 July 2007. Bioregional plans for the East, South-east, and South-west to be managed by DEWHA. Fisheries area sector management and specific spatial and temporal management within the boundary of the fishery, and mandatory and voluntary closures as outlined in the annual management plan 2007 and management arrangements 2009. Note substantial increase in uses of fishery closures in the past three years.
Environmental considerations	
Bycatch (includes TEPs, habitats, ecosystems)	The SESSF Bycatch Action Plan 2007-2009. Replaced with bycatch and discarding workplans 2009-2011 for the Great Australian Bight trawl fishery, South east trawl fishery, Shark gillnet fishery, and Automatic longline fishery,
Threat Abatement Plans	Threat Abatement Plan for the incidental catch or by catch of seabirds during oceanic longline fishing operations 1998, updated 2006. Implemented for the SESSF automatic long line fishery.
Economic considerations	
Economic	An ESD requirement. AFMA’s main focus on economic performance of the fishery sectors.

Table 8.3.3 continued: Summary of current operational management for the SESSF.

Summary of management for the SESSF	
Social considerations	
Social	An ESD requirement but in practice very limited application. Some social impacts were considered under the $220 million structural adjustment package.
Management assessments	
Management options (MSE)	Alternative management strategies for SESSF: qualitative and quantitative MSE (Fulton et al. 2004; and 2007).
Strategic assessments under the EPBC Act	2002 and 2006 for the purposes of an approved Wildlife Trade Operation (WTO). Declared an approved WTO until 22 December 2009 subject to conditions and recommendations. 18 Dec 2008 Minister issued a variation to the 2006 WTO and included additional provisions.
Risk assessment	Ecological Risk Assessment for the Effects of Fishing: SESSF Report for the Australian Fisheries Management Authority (2007). ERAs completed for sub-fisheries the Great Australian Bight report is publically available and the others will be made available in 2009/10. ERM framework approved by the Commission December 2008.
ESD assessment (national reporting framework)	No
Marine Stewardship Council (MSC) accreditation	No
Fishery performance assessment	
AFMA reporting requirements	AFMAs annual reports to parliament
Independent assessments	BRS annual fishery status reports; and ABARE annual Australian fishery statistic reports, annual fishery economic status reports; selected fishery survey reports.
Research and data	
Research plan	The Southern and Eastern Scalefish and Shark five Year Strategic Research Plan 2004-2009.
Monitoring and independent observer program	Monitoring logbooks, VMS, effort monitoring, compliance monitoring. Observer programs and ISMP Fisheries data summaries.

Key management and assessment documents for the SESSF (notices and announcements; the sectors; management of the fishery and its sectors; consultation; assessment; and publications) can be found on the Australian Fisheries Management Authority web page (Australian Fisheries Management Authority, 25 August 2009).

8.4 Recent AFMA management changes and addressing issues in the SESSF

AFMAs response to the Ministerial Direction required a number of significant strategic and operational management changes for Commonwealth managed fisheries. Some key aspects were to be applied to all Commonwealth fisheries such as the harvest strategy framework; application of the ecological risk management framework (ERM); implementation of independent surveys for input into stock assessments and indices of abundance; the introduction of ITQs; review of ITQs and boat SFRs; responding to discarding and bycatch issues; and the use of spatial management. Other key aspects specific to the SESSF included changes in the MAC structure; trialling of some aspects of a more delegated co-management approach; stock rebuilding strategies; and structural adjustments. The key strategic management changes and operational management responses in the SESSF are discussed below.

8.4.1 AFMA management changes

Management Advisory Committees (MACs)

As presented in Chapter 7, AFMA has a responsibility to consult with all stakeholders on fisheries resources when making management decisions regarding Commonwealth fisheries. This is achieved through the Management Advisory Committees (MACs) for each major Commonwealth managed fishery. In 2008/2009 there were twelve MACs operating, however as a result of a review in 2008, from 1 July 2009 the number of MACs was reduced to nine, and over the following three years will be reduced to six. As part of this restructure a new approach to receiving advice from stakeholders through a dual advisory model is to be established, with the MACs focusing on strategic issues and industry associations to focus on operational issues, when providing advice to AFMA (Australian Fisheries Management Authority, 2009 pp. 77-78). On 21 April 2009 AFMA sent a letter advising members SETMAC and GHATMAC would be combined to form the new South East MAC; and that GABMAC would continue until renewal was required in mid 2010.

Delegated co-management approach

As discussed in Chapter 7, there is interest in moving to a more delegated co-management approach. An AFMA funded project to determine the suitability of more delegated co-management arrangements, and evaluated the feasibility of introducing a more delegated co-management approach in selected Commonwealth fisheries. In 2008/09 co-management trials were undertaken in three fisheries (and will continue into 2009/10); these included the SESSF through the port of Lakes Entrance, Victoria and the Great Australian Bight trawl sector. Twenty of the twenty three SESSF vessels operating from Lakes Entrance voluntarily participated in a 12 month trial from May 2008 to April 2009. Under phase one of the trial AFMA, in co-operation with industry, developed a code of practice that outlined arrangements including automated transmission of catch disposal records, changes to quota reconciliation, and catch auditing processes. Phase two of the trial will run until April 2010 (Australian Fisheries Management Authority, 2009 pp. 2, 19, 22, 93). Co-management activities were undertaken with the GABTF during 2008/09, with more comprehensive arrangements developed with industry, to take effect in 2009/2010 (Australian Fisheries Management Authority, 2009 p. 93).

AFMA and the Great Australian Bight Industry Association Inc. (GABIA) held workshops and meeting between October 2008 and May 2009 to develop co-management arrangements for trialling in the Great Australian Bight Trawl Fishery (GABTF); and a guide to the respective roles and responsibilities of the Great Australian Bight Management Advisory Committee (GABMAC), Great Australian Bight Resource Assessment Group (GABRAG), GABIA and AFMA. It was agreed AFMA and GABIA will collaborate on the following co-management initiatives:

- Procedures for GABIA to make recommendations directly to AFMA on operational and commercial matters in the GABTF.
- A GABIA led precautionary strategy for setting long-term Total Allowable Catch (TAC) and catch trigger limits underpinned by cost-effective fishery monitoring and strategic research and stock assessment.
- A quota management strategy that is based on continual (rather than quarterly) balancing of quota holdings with catch.

- Investigation and implementation of a system to collect and record relevant fishery information to support and improve the ecological, biological and economic assessment and management of the fishery.
- Investigation and implementation of a ‘product traceability process’ that encourages optimising quality, efficient product handling, monitoring and reporting through the chain of custody from boat to receiver, with the intent to maximise market returns.
- Development of an operational procedures manual that incorporates a suite of operational and commercial requirements for the GABTF which will be administered by GABIA (Australian Fisheries Management Authority, 1 June 2009).

Ecological Risk Management (ERM) framework

The AFMA Commission approved the ecological risk management (ERM) framework for all commonwealth fisheries in December 2008. The framework details a process for assessing and progressively addressing the impacts that fisheries activities have on the marine ecosystem (including target, bycatch, and TEP species; habitats; and communities). The ERM framework involves a number of assessment stages. First, an ecological risk assessment (ERA) for each fishery (ERAs have been completed for all major Commonwealth Fisheries). This is followed by a Level two ERA residual risk assessment (based on a set of residual risk guidelines), which evaluates the ERA outcomes, taking into account additional information, particularly effects of current management arrangements, and any quantitative assessments. Outcomes from Level two ERA residual risk assessment, result in a priority list identifying the key species in the fishery that require management attention. Generally AFMA will address the risks through established policies and tools such as the Harvest Strategy Policy; Byproduct Policy; Bycatch and Discard Program; Chondrichthyan Working Group; and initiatives to minimise interactions with protected (TEP) species (Australian Fisheries Management Authority, 17 June 2009).

By July 2009 three fisheries had completed and published ecological risk management reports under the ERM framework, the remaining fisheries are to be completed during 2009/2010 (Australian Fisheries Management Authority, 2009 p. 20). One of the fisheries completed was the Great Australian Bight trawl sub-fishery of the SESSF. The risks that the Great Australian Bight Trawl Fishery (GABTF) posed to the sustainability of the marine ecosystem were assessed through the application of an ERA completed to Level two in 2007; a Level two PSA residual risk assessment completed in 2008; and a rapid quantitative risk assessment completed in 2008. As a result the priority list of species to be addressed in the GABTF, were for two invertebrates the cuttlefish (various species) and the octopods (various species) both of which are byproducts in the fishery. These species come out at high risk because of lack of information (Australian Fisheries Management Authority, 8 February 2010). It should be noted that the response by AFMA (in terms of a formal response or developed strategies) under the ERM has focused on species not habitats or communities.

ITQs and boat SFRs

The Ministerial Direction required AFMA to conduct a cost-benefit analysis to determine whether boat permits and/or boat SFRs were an impediment to autonomous adjustment, or were otherwise a barrier to efficient fisheries management, and if this was the case, whether they could be phased out by 2010. The fisheries of interest included the Northern Prawn, Eastern Tuna and Billfish, Western Tuna and Billfish, and the SESSF. AFMA reported that most management advisory committees (MACs) were concerned about the removal of boat SFR/permits because they provide access to non-quota and non-target species, and are an asset they hold (Australian Fisheries Management Authority, 2006 p. 188; Australian Fisheries Management Authority, 2007 p. 214). Input based SFRs include boat SFRs, these provide a right to operate a vessel in the fishery (defined in terms of area and gear that can be used); and gear SFRs, which define the amount of gears that can be used or the level of fishing effort (days fished). Output, for example; SFRs include quota SFRs (effectively ITQs), which define the share of the total allowable catch of a particular species that can be taken by a vessel. In other fisheries access is limited by boat permits. Both specify the fishery in which the boat may operate, along with the gear that may be used, and are effectively boat licences. For fisheries that employ boat SFRs or permits these are used to effectively limit boat numbers and access to either a particular area and/or the use of particular fishing gear. Boat SFRs or permits also play a role in compliance and enforcement. A key role of boat SFRs or permits is restricting access to a fishery where not all species are subject to quota control.

In Australia a key concern of managers, was that any benefits from the restructuring (as discussed above under *Securing Our Fishing Future*) would not be retained if capacity was allowed to rebuild, and mechanisms to enable autonomous adjustment should be adopted. Pascoe and Gibson (2009) studied the role of boat licences in ITQ managed fisheries in Australia. A key perceived benefit of rights based fisheries management (for example ITQs and with similar expectations for ITEs) is the ability of the fleet to adjust autonomously, and to remove excess capacity. As outlined in the stiudy some economists have argued that these types of licence are no longer needed for fisheries managed under a rights based system. However, in all cases examined the actions needed to replace the function of boat SFRs, would result in higher management costs, higher transaction costs and reduced efficiency of the industry. The study concluded that any impediment to autonomous adjustment which is produced by boat licences is likely to be small relative to other factors (Pascoe and Gibson, 2009).

As Pascoe and Gibson (2009) highlight, in Australia boat licences play a key role in preventing new boats from entering the fishery. Expectations of increases in profitability in the fisheries following the industry restructuring could encourage new vessels to enter the fishery. The current availability of quota in the SESSF (were between 40-60% of the quota of many species is held by non-fishing entities) would enable new boats to enter, if the additional entry control was not in place. In the Great Australian Bight Trawl Fishery (GABTF) the current management system provides for an equal share in the fishery for all boat SFR holders. Removal of the boat SFRs could turn a co-operative fishery into a competitive fishery, as there would be no equivalent basis by which fishing companies could co-operate. The value of this co-operation is reflected in the high value attached to the boat SFRs ($1.8 to $3 million based on industry/broker estimates for 2007). A key role of boat licences is concerned with restricting access to a fishery when not all species are subject to quota controls. Even delineating TACs by stock would give Commonwealth trawl vessels access to GABTF non-quota species, and likewise GABTF vessels could move into the Commonwealth Trawl Fishery. However, due to the higher profitability of the GABTF fishery it is more likely to result in a transfer of fishing activity into the GABTF, to the detriment of the existing fishers. Similarly the southern shark gillnet fishery overlaps with the shark hook fishery, and catches the same species, but the fishing grounds of the gillnet fishery are more extensive than the hook fishery. Replacement of boast SFRs with minimum quota holdings could enable the current hook boats to reconfigure as gillnet boats, effectively increasing the level of effort in the gillnet fishery at a cost to the existing fleet. The boat SFRs also limit the amount of gillnet that can be used by each fisher and removing this restriction may result in increased bycatch (Pascoe and Gibson, 2009).

8.4.2 Addressing issues in the SESSF

Some key issues and management responses as they relate to the SESSF include the harvest strategies; stock rebuilding strategies; structural adjustments; discarding and bycatch; and protected species.

Harvest strategies

A harvest strategy framework for the SESSF was developed in 2005, with its first application to setting of TACs for the 2006 fishing year (Smith and Smith, 2005; Smith, et al. 2008). The development of the strategy did not commence until 2005 and the process was completed within three months, and this short time frame did not allow the harvest strategy framework to be tested for performance and robustness prior to adoption. In the SESSF there is a large number of species and stocks in the quota system, and less than half of them had been assessed using quantitative stock assessments. Therefore a single harvest control rule could not be applied, and a four tiered approach was adopted. Tiers 1 and 2 were used for stocks for which there was a quantitative stock assessment that provided estimates of current absolute and relative biomass (with Tier 1 regarded as robust and Tier 2 as less certain or with a preliminary assessment); Tier 3 was based on current fishing mortality derived from catch curves (requiring age and/or length frequency data, but not catch rate or abundance); and Tier 4 was based on recent trends in (commercial) catch rates. Each Tier has a formula used to estimate the recommended biological catch (RBC) (Smith et al., 2008).

Application of the harvest strategy framework resulted in a number of achievements. The TAC setting process was quicker and less contentious; TACs were generally set below the RBC level to account for state catches and discards. This provided industry with an incentive to reduce discards of quota species. The Tier approach has the ability to deal with stocks with a range of information availability, from data rich to data poor. Several lessons were learned from implementing harvest strategies in the SESSF. If more time had been spent developing and testing the framework and strategies, prior to implementation, several of the issues particularly for Tiers 3 and 4 could have been avoided. Management strategy evaluation (MSE) techniques were not used to formally test the harvest strategies until 2006. Developments in the Commonwealth Harvest Strategy Policy, defined the target levels and limits to be achieved, as well as the acceptable levels of risk in not meeting the limits. This information on objectives was considered crucial in developing performance strategies, but was not available for harvest strategies introduced into the SESSF in 2005. The most significant change since 2005 has been the policy decision of applying B_{MEY} rather than B_{MSY} as the target (Smith et al., 2008). In 2007 further work was undertaken to refine the SESSF harvest strategy framework, the revised HSF was applied in 2008 (Morison et al., 2009c pp. 107-108).

Since the introduction of the HSP, efforts have continued to develop and improve harvest strategies for Commonwealth managed fisheries, particularly for stocks for which there is limited information. An unresolved problem is the setting of a single fishery-wide TAC for a species when the fishery exploits more than one stock. In the SESSF, this problem has resulted in pink ling being classified as subject to over-fishing due to high fishing mortality of the eastern stock, which is depleted to below target biomass levels, while the western stock is not subject to over-fishing. The HSF does not address the need to control catches of commercially valuable non-quota species (this has been an ongoing issue since ITQs were introduced in 1992). Although quotas have been introduced since the implementation of TACs for deepwater shark species, ribaldo and oreo dories, but other non-quota species are still being actively targeted. There are also issues regarding carryover allowances where TACs have been set at low levels to cease targeted fishing for over-fished species, but where there are TAC carryovers for such species. For example, this practice led to the actual TAC for orange roughy in 2007 being three times the initial agreed TAC that was set to cover incidental catches. The reliability of the decisions made under the harvest strategy also depend on the quality of assessments that support it (i.e. data collection systems, observer and port sampling systems, and independent reviews) (Wilson et al., 2009 pp. 39, Morison et al., 2009c p.166).

Stock rebuilding strategies

Three stock rebuilding strategies were put in place in 2008 for the eastern gemfish, school shark and blue warehou. Stock rebuilding strategies outline the life history of the species and the key threats; the status of the resource; the objectives of the rebuilding strategy; management objectives to achieve the strategy including issues with recent management and any new management arrangements required; and monitoring and recovery and performance measures. An example provided here, is the School Shark Rebuilding Strategy 2008.

As outlined in the *School shark stock rebuilding strategy 2008*, the school shark has been assessed as over-fished since the Bureau of Rural Sciences commenced Commonwealth fishery status reports in 1992. The life history characteristics (long lived, late maturity and low fecundity) of the school shark make it vulnerable to over-fishing. The main threats identified were fishing pressure, and habitat degradation (from coastal development and pollution) of key coastal habitats used as pupping areas, and seagrass associated feeding grounds. The management arrangements to achieve the stated objectives include closures of areas that are important aggregation areas for school sharks both as pupping and nursery grounds for juveniles; and for the migration of pregnant females, towards the pupping grounds. All coastal sites confirmed by research as pupping grounds have been closed to fishing in Victoria and Tasmania. Additional closures of coastal and deepwater habitat known to be important for school sharks were implemented between 2003 and 2005 these were to protect breeding age school sharks, with further closures in 2008. Gear restrictions and selectivity measures, regarding gillnets, have been implemented, and all automatic longline vessels are restricted to a maximum of 15,000 hooks, to minimise the impact of this method on bycatch species (to assist school shark recovery as they are highly susceptible to capture by hook). The key parties affected by the strategy are fishers operating in the gillnet, hook and trap sectors of the SESSF. As part of the structural adjustment 26 of the 88 gillnet boat Statutory Fishing Rights (SFRs), and 17 of the 30 shark hook SFRs were removed. Most of those remaining are not actively used, but this sector will be monitored and impacts assessed (Australian Fisheries Management Authority, 2008).

The BRS *Fishery Status Report 2008* classified the school shark as over-fished, but over-fishing status as uncertain. The assessment is based on the Tier 1 modelling approach; however, there is much uncertainty over the interpretation of logbook catch and effort data since 1997. Current data is insufficient to determine whether school shark are subject to over-fishing or that stocks are rebuilding. Data from the 2007 and 2008 surveys will be incorporated into an updated school shark assessment to be undertaken in 2009. The level of pup production relative to pre-fishery (1927) levels is used as the major reference point of stock status. Pup production was estimated to be below 20% of the 1927 level; thus, the RBC for the species was zero. The global school shark bycatch TAC was set at 240t. for 2007, in line with the agreed harvest strategy to account for non-targeted incidental catch. The strategy requires a constant TAC of 240t. from 2007 that is intended to bring about rebuilding by 2024. Research surveys of school shark nursery areas in eastern Tasmania and central Victoria in the early 1990s indicated a much lower abundance of pups than when the same areas were studied in the 1950s. Urbanisation near these areas and subsequent pollution and degradation of critcal habitats are likely to have affected pup abundance. Therefore, the relative importance of the effects of fishing is not known. In February 2009, school shark were listed as conservation dependent under the EPBC Act. The listing does not prevent the take of school shark as bycatch, but fishing must be conducted in accordance with AFMA's management plan and the rebuilding strategy as required by the Commonwealth Harvest Strategy Policy (McLoughlin and Wood, 2009 pp. 192, 194, 199).

Listing of orange roughy as conservation dependent

Within the Commonwealth trawl sector of the SESSF there are four orange roughy management zones, the eastern, southern, western and Cascade Plateau. Orange roughy (SESSF stocks) have been divided into three separate stocks based on biological information eastern, southern and western; and orange roughy on the Cascade Plateau, also appear to be a distinct stock. The BRS *Fishery Status Report 2007* and *Fishery Status Report 2008* classified orange roughy as over-fished but not subject to over-fishing for the eastern, southern, and western zones and not over-fished and not subject to over-fishing on the Cascade Plateau zone. The assessments for the eastern, southern and western zones were not updated for 2008, but will be reviewed in 2009, as required by the Orange Roughy Conservation Programme (Morison and McLoughlin, 2008 pp. 137-143; Morison et al., 2009c pp. 113-114, 143-146).

In November 2006 the Minster for the Environment and Heritage listed orange roughy as conservation dependent under the *Environment Protection and Biodiversity Conservation Act (EPBC) 1999*. This was the first commercially harvested species to be listed under the EPBC Act. The decision by the Minister not to list orange roughy under a higher category was due to AFMA having already established a Conservation Program for the species. Eligibility for listing a fish species as conservation dependent requires that there is a formal management plan (in this case under Commonwealth law) which provides the necessary actions to stop the decline and supports the recovery of the species (Morrison and McLoughlin, 2008 pp. 137-143). As outlined in the orange roughy conservation program the risk of future listing to a higher category is dependent upon recovery in the over-fished and over-fishing zones. Orange roughy are long lived and slow to mature species, making them vulnerable to over-fishing. The program aims to maintain the spawning biomass on the Cascade Plateau at or above B_{60} (60% of unfished levels) and in the over-fished zones minimise the take of orange roughy. The actions to achieve the stated objectives include a direction (implemented in 2007) not to fish in waters deeper than 700m, in the SESSF, and 750m in the Great Australian Bight Trawl Fishery (GABTF) trawl sector of the fishery. These restrictions were subsequently revised to allow up to 50% of areas to be re-opened, but in such a manner that minimised orange rough catches, and minmised impacts to deepwater sharks. Targeted commercial fishing for orange roughy will only be permitted in the Cascade Plateau zone. Bycatch TACs are to be reviewed annually, and it will be an offence to take orange roughy in excess of allocated quota holdings. The population of orange roughy in Australian waters is known to be comprised of more than one stock and it may take many decades to recover the severely depleted populations to target levels within a biologically reasonable timeframe, which is expected to be approximately 40 to 45 years. The monitoring strategy comprises a high precision multi-frequency acoustic survey of abundance at five yearly intervals; low precision surveys to observe stock movement distributions; and otoliths collected at three to five yearly intervals for ageing. AFMA is to undertake an annual review of the program, and it will be formally reviewed after five years (Australian Fisheries Management Authority, 4 January 2010).

Structural adjustment

As discussed in Chapter 7, the SESSF was one of the four targeted fisheries as part of the *Securing our Fishing Future* package announced in 2005. Under economic conditions at that time, many Commonwealth fisheries were considered to be incapable of self adjusting and the package aimed at providing a one-off opportunity for fishers to leave the fishery; to address the issues of sustainability and profitability by reducing the number of fishers; and was to be combined with the introduction of harvest strategies to eliminate over-fishing and manage the broader ecological impacts of fishing. It also coincided with the release of a proposal to create a network of Marine Protected Areas (MPAs) in the south-east region. The structural adjustment package would also address the displaced fishing effort as a result of these proposed MPAs (Department of Agriculture, Fishing and Forestry, 26 October 2009). Buxton et al. (2006) undertook a regional impact assessment for the marine protected areas proposed for the South-east region. Outcomes from the study resulted in the establishment of an alternative MPA network that did not alter the biodiversity conservation outcomes of the original DEWHA proposal; provided a small increase in the proportion of shelf under MPA protection; decreased the impact of the MPA network on the fishing industry by over 80%; and minimised the potential compensation for MPA displacement under the Commonwealth's structural adjustment package (Buxton et al., 2006 p. 5).

While economic gains can accrue to both fishers who exit, or remain in the fishery, these are not the only measure of sustainability of the industry. The relationship between the viability of fishing communities is also important, as it may result in a negative impact on their social dynamics. This was highlighted where number of towns in southern NSW lost the majority of their fleet. Where there is an abrupt decline in the population of active fishers sustaining the continuity of knowledge transfer across future generations, may also impact social capital (Minnegal and Dwyer, 2008).

In fisheries subject to ITQ management many quota holders do not hold a fishing concession, but lease quota to active fishers. In 2007 approximately 25% of the 100 quota holders in the shark fishery were not active fishers. According to Pascoe and

Gibson (2009) it is therefore doubtful whether the economic position of the average fisher as reflected in their access to fish, was substantially improved after the buyout. The buyout package also included a subsidisation of levies on a reducing scale, for a three year period only, and unless management costs were reduced, the remaining fishers could expect an increase in administrative charges.

Vieira et al. (February 2010) undertook an analysis of the impact of the structural adjustment on the profitability of Commonwealth fisheries. For the Commonwealth trawl sector prior to the buyback of the 118 trawl SFRs 33 were latent (28%), the buyout resulted in a 50% SFR reduction, post buy back of the 59 remaining concessions 45 were active and 14 latent (24%). Prior to the buyout the net economic return (NER) was zero to negative, post-buyback NERs have increased, from $1.6 million in 2005/06, to $3.6 million in 2006/07; and $7.1 million in 2007/08. Although total revenues declined over the period by 13% this was outweighed by a 30% decline in total operating costs, except for management costs. Management costs have increased by 50% over the same period (Vieira et al., February 2010 pp.50-61). For thegillnet, hook and trap sectors the buyback resulted in a reduction of 30% of gillnet, 52% of shark hook and 57% of scalefish hook boat SFRs being removed from the fishery. Of the 144 boast SFRs/permits purchased only 17 boat SFRs and 9 coastal water permits were tendered by active boats. In total only 17 active boats (in 2005/09) had permits purchased in the buy back, however this did not necessarily mean that all these boats exited the fishery, as many operators hold multiple boat SFRs or permits (analysis showed, that four still fished in the sector in 2007/08). Unlike other Commonwealth fisheries the NER in this sector were generally positive prior to the buyback, between 1999-2000 and 2005/06 average NER was $1.3 million. Post-buyback NERs have increased, from $1.0 million in 2005/06, to $1.5 million in 2006/07; and $5.0 million in 2007/08. Unlike other fisheries targeted in the buyback operating cost were estimated to have increased by 15%. Total management costs also increased despite the reduction in vessel numbers (from $2.1 million in 2005/06, to $2.5 million in 2006/07, before reducing slightly to $2.2 million in 2007/08) (Vieira et al., February 2010 pp.61-73).

Discarding, bycatch and protected species

There is a wide variation in the level of discarding across Commonwealth managed fisheries. Discards are factored into TAC setting processes for quota managed species. Effectively implementing the policy of no discard for quota species and target species, by the end of 2007; and reducing bycatch rates by 50% by mid 2008 remained problematic in most fisheries (Australian Fisheries Management Authority, 2006 p.188; Australian Fisheries Management Authority, 2007 p. 215). AFMA established a Bycatch and Discarding Program in February 2007 to provide additional resources and direction for pursuing policy and legislative objectives in relation to bycatch and discarding. AFMA is currently moving from its existing Bycatch Action Plans (BAPs) to a more focused approach in the form of Bycatch and Discard Workplans. AFMA is to co-ordinate the efforts of various interest groups in developing these workplans by establishing bycatch and discard working groups consisting of scientific, industry, government and conservation members. These workplans identify the specific bycatch issues in a fishery based on the outcomes of the ERA and ERM processes, and details actions required to address the issues. The main areas covered are protected species and ecological communities; high risk and other bycatch species; and the broader marine ecosystem. The workplans are to be integrated into the management arrangements for the fishery, to enable the actions to be implemented. These workplans will be reviewed every 12 months, and formally renewed every two years. Until the new workplans are in place, each fishery was expected to report to their existing Bycatch Action Plan (Australian Fisheries Management Authority, 29 September 2009).

Protected species listed under the EPBC Act include seabirds, marine mammals, marine reptiles and some fish species. AFMA addresses the issue of interactions with these species as a result of fishing activities through development and implementation of mitigation measures. These include gear modification and other measures as outlined in the bycatch and discarding workplans; Treat Abatement Plans; measures to avoid incidental capture; and handling practices to release species and return them live to the sea. Fishers are required to report interactions with TEPs. To help with identification a protected species ID guide (Australian Fisheries Management Authority, 2006) was provided to all Commonwealth fishers; and TEP species management fact sheets that provide information on specific mitigation measures was produced (Australian Fisheries Management Authority, 4 December 2009).

The SESSF Bycatch Action Plan 2007-2009 (Australian Fisheries Management Authority, March 2007) was the first combined BAP for the fishery, and remained in place until it was replaced by bycatch and discarding work plans. Since then four bycatch and discarding workplans have been developed for the SESSF. These are the Great Australian Bight Trawl Fishery (GABTF) November 2008 (actions cover the 2008/2009 period); and the Commonwealth Trawl Fishery (otter board trawl and Danish seine), Shark Gillnet Fishery, and Automatic Longline (ALL) Fishery for the period 1 July 2009 to 30 June 2011 (Australian Fisheries Management Authority, 25 January 2010). An example, for the Shark Gillnet Fishery is provided below.

As outlined in the *Shark Gillnet Fishery bycatch and discarding workplan 1 July 2009 to 30 June 2011*, although the selectivity of demersal gillnets is managed through mesh size restrictions, fishing does result in the catch of different species, some of a size that is uneconomical to retain, or for which there are no markets and are discarded. Two of the most commonly caught bycatch species are draughtboard sharks and Port Jackson sharks. These species are caught in high numbers in the gillnet fishery and are mostly discarded due to their low market value. Result of the Rapid Level three ecological risk assessment classed eight species (all chondrichthyans) as high risk; and four TEP species (white sharks, Australian sea lions, and the Australian and New Zealand fur seal) as high risk as a result of the Level two residual risk assessment. Existing bycatch reduction efforts are through improved fishing gears (with 15.0-16.5 centimetres mesh sizes mandated in the fishing permit requirements); and temporal and spatial closures (shark gillnet and hook operators excluded from fishing deeper than 183m to prevent targeting of adult school shark, and in effect benefit gulper shark populations). The key objectives of the bycatch and discarding work plan for calendar years 2009-11 are:

- respond to key high risk species and take steps to increase the knowledge of all high risk species and their interactions with the fishery;
- develop a longer-term response plan for all remaining high risk species based on scientific advice;
- develop measures to mitigate interactions with TEP species; and

- ensure through independent monitoring that robust estimates of discarding are made and used in the harvest strategy (Australian Fisheries Management Authority, 25 January 2010).

Chondrichthyan Technical Working Group

Generally, chondrichthyans (sharks, skates and rays) are slow growing, late maturing, have low fecundity, are vulnerable to exploitation and are slow to recover. These species are caught incidentally and may not survive when returned to the sea. There are currently 12 shark species listed as protected in one or more Australian jurisdictions. Three additional species, the Harrison's dogfish, southern dogfish, and endeavour dogfish, are being considered for listing. Chondrichthyans were identified as high risk species through the ERM process . To address this issue AFMA established the Chondrichthyan Technical Working Group (CTWG) to develop practical mitigation options for the high risk chondrichthyan species and groups. The CTWG produced a *Chondrichthyan guide for fisheries managers: a practical guide for mitigating chondrichthyans bycatch* (Patterson and Tudman, September 2009) which provides biological information on the chondrichthyan species and groups; high risk fisheries and gear types; and summary of current management or mitigation strategies. General recommendations included improved handling practices and trip limits. The CTWG concluded that there was no panacea to the problem, but the guide provided managers with the most appropriate options to mitigate fisheries impacts. Many of the high risk chondrichthyan species are caught in the SESSF fishery sectors.

8.5 Western Australian fisheries management framework under ESD and EBFM principles

A brief overview of Western Australian (WA) State managed fisheries and the recent Department of Fisheries (DoF) management changes will be presented as background and as an introduction to the case study fishery the West Coast Rock Lobster Fishery (WCRLF).

8.5.1 Biological and economic status of Western Australian fisheries sectors

The DoF manages commercial wild caught, recreational, and indigenous fishery sectors and aquaculture. Many of the significant fisheries are regionally based which contribute to the regional lifestyle and culture, and provide employment. Indigenous fishing issues and the development of the law in respect to Native Title have highlighted the need for recognition and inclusion of Indigenous interests as a fishing sector. DoF has developed an Aboriginal Fishing Strategy focused on recognition of customary fishing, economic development opportunities and improving the opportunities for Aboriginal involvement in management of the State's fisheries (Department of Fisheries, 2008 p. 18). In 2007/2008 the key wild caught species were rock lobster, prawns, and abalone and for aquaculture pearls. The gross value of production (GVP) was A$448 million (7% decline on 2006/2007) representing 20% of total fisheries production in Australia. The decline was due to a decrease in the value of production mainly from weaker prices of wild caught crustaceans; and in the value of aquaculture production of cultured pearls, but was offset by an increase of GVP of other aquaculture species mainly of cultured fish. The value of production by groups and main species within these groups (from highest to lowest) was crustaceans A$250 million (rock lobster $217m, prawns $27m, crabs $6m); aquaculture $123 million (pearls $113m, fish $4m, marron $2m); molluscs $41 million(scallop $18, abalone $10m); fish $325 million (tropical $9m snapper $5m, shark, pink snapper $5m) (Pham and Peat, 2009 pp. 8, 10, 50). The total number of people employed in WA fisheries (including post harvest) sectors (ABS census data, as at August 2006) was 2,286 (5th after QLD, NSW, SA and VIC). The numbers employed in production was 1,477 (65% of total) with rock lobster fishery 491 people and aquaculture 325 people; and post harvest sectors 809 (35% of total) with 452 people in fish wholesaling and 357 in seafood processing (Pham and Peat, 2009 p. 27).

The DoF produces annual state of the fisheries reports which provide a wide range of information regarding WA managed fisheries (such as the status of fish stocks and environmental assessments). A summary of this information is included in the DoF annual reports to parliament. The *State of the fisheries report 2008/09* reported that fishing generally does not present an unacceptable risk to most of the targeted stocks or the marine, estuarine and freshwater ecosystems. The majority of fisheries have been assessed as having negligible or minor risks of unacceptable impacts on bycatch species, protected species, habitats or the broader ecosystem. For those fisheries assessed as having a high risk to one or more elements, they have still met their annual performance targets (Fletcher and Santoro, 2009 p. 5).

The stock status and catch ranges for major commercial fisheries are generally considered adequate, with two breeding stock assessments classed as recovering (Cockburn Sound crab and Shark Bay snapper). The west coast demersal scalefish breeding stock assessment was considered inadequate, but catch levels were acceptable. The northern shark breeding stock was assessed as depleted; and in the southern and west coast demersal gillnet and longline the stocks of gummy and whiskery sharks are recovering but the dusky and sandbar shark breeding stock assessments are classified as depleted. The south coast crustacean breeding stocks are uncertain and the stock assessment for the Australian herring is also uncertain (Fletcher and Sanotor, 2009 pp. 262-266).

For commercial species subject to export approval under the EPBC Act, where current annual performance for the 2007/08 season, or the calendar year 2008 were assessed as not acceptable by DoF were as follows. The Northern Demersal Scalefish Fishery, red emperor, goldband snapper, cods/groupers species performance (spawning stock) was not met; increasing trend in catches for these species has triggered the requirements for an updated stock assessment which is currently in progress. Shark Bay prawn fishery, king prawn (spawning stock), although performance was not met, it was considered acceptable; due to reduced efforts and targeting of larger size prawns and small shift of effort to scallops (Fletcher and Sanotor, 2009 pp. 285, 289). Scientific evidence indicated some recreational fisheries were at risk, and an independent review confirmed that over-fishing was occurring in demersal species such as dhufish, pink snapper and baldchin groper. New recreational (and commercial) rules were introduced in January 2009 to protect these demersal finfish species. This was necessary because of human population growth in the area, the popularity of recreational fishing activities, and uptake of high tech fishing equipment. WA is forecast to be one of Australia’s growing states, with population predictions of more than 2.7 million by 2030 (Department of Fisheries, 2009 p. 5).

8.5.2 Department of Fisheries managed fisheries under ESD and EBFM principles

As part of the DoF’s Strategic Plan 2009-2018 amendments to the *Fisheries Resource Management Act 1994* (FRMA) are to be drafted to include provisions for the development of a world scale aquaculture industry (for possible enactment in 2009); and reforms to the FRMA and *Pearling Act 1990* are to reflect contemporary practice and requirements (for possible enactment by 2010). The intention is to produce a new fisheries act that will encompass fisheries management, aquaculture and pearling (Department of Fisheries, 2009 pp. 4-5).

DoF is committed to the principles of ESD through the objects of its primary enabling legislation the *Fish Resources Management Act 1994 (FRMA).* It operates using an ESD policy that incorporates an ecosystem based fisheries management approach. This approach includes managing human impacts on target species, bycatch species and habitats, plus any potential indirect impacts of fishing and aquaculture activities on the broader ecosystem. It also includes managing social and economic impacts of fishing and aquaculture activity (Department of Fisheries, 2009 p. 15). The fishery sectors are managed under ESD principles, and fishery related activities are managed on a bioregional basis, which according to WA enables EBFM, to be more efficiently considered (Fletcher and Santoro, 2009 p.5). Fisheries are managed under two bioregions the Northern and the South-west bioregions. The Northern bioregion area covers the area north of Kalbarri to the Western and Northern Territory border and includes two distinct coastal bioregions the North coast (Pilbara and Kimberly) and the Gascoyne coast; and the Northern inland region The South-west bioregion stretches from Kalbarri to the South Australian border on the south west coast. The South-west bioregion contains two distinct coastal bioregions the West coast and the South Coast; and the southern inland region (Department of Fisheries, 2008 pp. 34-40).

The EBFM framework is a risk based management approach, which recognises the social, economic and ecological values at a regional level, and links between exploited fish stocks and the broader marine ecosystem, to ensure sustainable management of all fisheries resources. The EBFM framework identifies these individual values, and provides a mechanism for reporting on their status, and the fisheries management arrangements that are being applied. The West Coast is the first bioregion where the

EBFM process has been applied (it will be applied in the other bioregions in the near future). In terms of assets the ecological values recognised are ecosystem structure and biodiversity; capture fish species (stock sustainability); protected species interactions; benthic habitats; and general environmental impacts (Fletcher and Sanotor, 2009 pp.5-8).

The Integrated Fisheries Management (IFM) initiative aims to manage Western Australia's fisheries in a manner which shares the overall catch between commercial, recreational, charter, and indigenous fishers in a sustainable manner. The *Integrated Fisheries Management Government Policy* (Department of Fisheries, 1 October 2004) outlines the guiding principles for management which form the basis for integrated fisheries management, and the allocation and compensation processes. The policy is being progressively phased in over a number of years as more fisheries are brought under the integrated management framework. A guide to Integrated Fisheries Management (Department of Fisheries, June 2006) outlines the IFM initiative in more detail. The IFM policy is part of the WA Government's fisheries strategic policy, is a key element of its ESD policy, and the associated State Sustainability Strategy.

The key IFM policy guiding principles include setting a harvest level that incorporates total mortality for each fishery with explicit allocations designated for use by each group. The allocations to user groups should account for the total mortality of fish resources resulting from the activities of each group, including bycatch and mortality of released fish. It should also incorporate pre-determined actions which are to be invoked if that group's catch increases above its allocation, so future sustainability is not compromised. A sustainability report is to be prepared for each fishery in accordance with the Policy which includes a clear statement on the harvest level (Department of Fisheries, 1 October 2004 and updated 2009). For a resource that is fished by a single sector with little interaction with other sectors, there may be no need to consider the allocation of shares. However, for fish resources where there is a high level of interest and interaction from several sectors, or where the catch is shared, it is likely that substantial work will be required to determine the allocations. The IFM process generally involves four stages, determining the need for a formal allocation process in a fishery; development of an IFM report by the Department of Fisheries; the integrated fisheries allocation process (investigation of the allocation issue; draft allocation report for public comment; recommendations and Minister's determination); and mechanisms for future allocations between sectors (Department of Fisheries, June 2006 pp. 11-13).

8.6 The West Coast Rock Lobster Fishery: a case study

A brief overview of Western Australian managed fisheries and recent management changes for the Department of Fisheries, will be presented as background and introduction to the case study fishery the West Coast Rock Lobster Fishery (WCRLF).

8.6.1 Overview the West Coast Bioregion

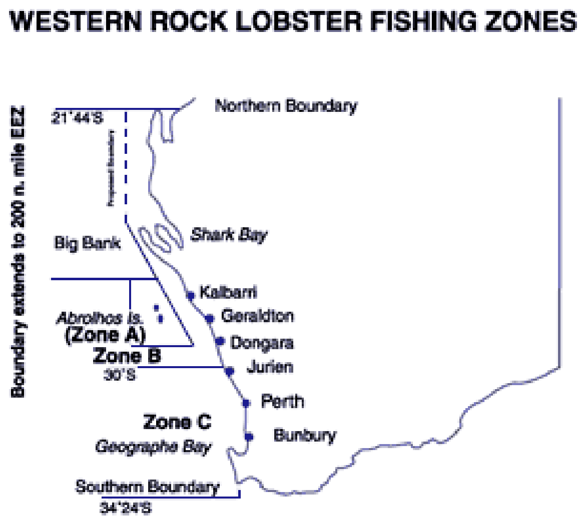
The marine environment of the West Coast Bioregion between Kalbarri and Augusta is predominantly a temperate oceanic zone, and is heavily influenced by the Leeuwin Current which transports warm tropical water down the continental shelf. The most significant impact of the clear, warm, low nutrient waters of the Leeuwin Current is on the growth and distribution of temperate seagrasses. These form extensive meadows in all protected coastal waters in depths of up to 30m. and acts as major nursery areas for many commercial and recreational fish species, particularly the western rock lobster, which is the principal commercial fishery in this region. In this region, more than any other in the State, population growth poses specific challenges for fisheries management. Increased recreational fishing pressure, and the setting of catch shares for commercial and recreational users, remains a major focus for the DoF. The West Coast Bioregion is the most heavily used area for recreational fishing owing to its accessibility to the main population centres. Marine habitats are largely protected from any physical impact of commercial fishing by extensive closures to trawling. These closures, introduced in the 1970s and 1980s, protect seagrass and reef habitats, with trawling limited to sand areas inhabited by target species such as scallops. In addition, habitat and biodiversity protection is provided by specific Fish Habitat Protection Areas, Reef Observation Areas, and marine parks in sensitive areas. These protective management measures have contributed to maintaining the marine habitat and biodiversity in generally good condition. However, nearshore estuaries and some protected nearshore waters and fish habitats in the bioregion now face major threats from coastal development and environmental degradation through terrestrial runoff (Fletcher and Santaro, 2008 pp. 10-12; Fletcher and Santoro, 2009 p. 10).

The risk levels for each of the ecological assets are classified as follows. Low and medium values are both considered to be acceptable levels of risk. High and severe risks indicate the asset is no longer in a condition which is considered appropriate and that additional management actions are required. Where values are followed by (non-fishing) this indicated that all, or the majority of the risk value was not generated by fishing activities (Fletcher and Santoro, 2009). The West Coast Bioregion ecological assets in 2008/2009 were reported as:

- *Ecosystem and biodiversity assets:* estuaries were classified as severe risk (non-fishing) due to external factors (water quality, nutrient runoff) which have the potential to affect fish and other marine communities.
- *Captured fish species:* inshore demersal (20-250m depth) classified as severe risk (dhufish, pink snapper, baldchin groper, sharks, western blue groper). Concerns for demersal species were confirmed by stock assessments and recent reviews. Management actions have been taken, and catch shares for commercial and recreational fishers is now a management focus. Nearshore demersal (0-20m depth) classified as high risk, increasing concerns for Australian herring, tailor, skipjack trevally and King George whiting, research projects have begun to assess these stocks) in the nearshore region (given the potential for fishing levels to increase on these stocks once the management of inshore demersal stocks commences). Offshore demersal (>250m depth) classified as medium/high risk, some of the key indicator species in deepwater locations are vulnerable to over-fishing, management arrangements for commercial and recreational fishing are still being finalised. Crustaceans in the estuarine zone are classified as high risk. The stocks of crabs in Cockburn Sound have been at depleted levels for the past few years, but are now in the process of recovery since the closure of fishing in 2007. The other stocks of crabs are being investigated.
- *Protected species:* all were classified as low or medium risk.
- *Benthic habitat:* estuaries and embayments sand was classified severe (non-fishing) risk, issues of poor water quality, loss of habitat through coastal development and physical disturbance, sedimentation and smothering by algae. There are minimal impacts of fishing on these habitats (Fletcher and Sanotor, 2009 pp. 13-16).

The DoF is developing a framework to assess the most appropriate methodologies for implementing EBFM. Qualitative modelling was used to investigate five separate systems within the West Cost Bioregion. The ecosystem dynamics and the importance of social and economic links were examined using different scenarios for each of the five systems. These were: the role of stakeholders in influencing Government decisions; management needs in Cockburn Sound; the impacts of the market on the western rock lobster fishery; and alterations to recreational fisher behaviour following hypothetical changes in management. The formal assessment of these management systems provided an understanding of the issues to be considered when implementing EBFM (Metcalf et al., 2009).

West Coast Rock Lobster fishery sectors



Commercial sector

The commercial West Coast Rock Lobster Fishery (WCRLF) is Australia's most valuable single species wild capture fishery. The WCRLF targets the western rock lobster, *Panulirus cygnus*, on the west coast of WA between Shark Bay and Cape Leeuwin, using baited traps (pots). The fishery is managed in three zones: south of latitude 30^{o} S (Zone C); north of latitude 30^{o}S (Zone B); and within in the northern area, a third offshore zone around the Abrolhos Islands (Zone A). In March 2008 the Minister's decision regarding allocation of resources between the sectors (under the Integrated Fisheries Management arrangements) were 95% to the commercial sector and 5% to the recreational sector. The 2007/2008 catch for the WCRLF was forecast from puerulus settlement three to four years previously and was predicted to be 8,940t. The actual catch from the WCRLF for the 2007/2008 season was 8,920t, which was 19.5% lower than the long-term average catch (1980/1981 to 2005/2006) of 11,083t and 4% higher than the previous season's catch of 8,577t. The 2007/2008 catches for Zone A were 1,881t (6% lower than the previous season); Zone B was 3,087t; (up 4% on the previous season) and Zone C was 3,952 t (up 9.5% on the previous season). Variance in catch rates are primarily due to varying levels of recruitment, which are driven by environmental conditions (de Lestang et al., 2009 pp. 19-21).

Recreational sector

The recreational rock lobster fishery operates state-wide and encompasses the take of all rock lobster species. Fishing is concentrated in the inshore regions in depths of less than 20 metres between North West Cape and Augusta. The recreational rock lobster fishery primarily targets western rock lobsters off the Perth metropolitan area and Geraldton, using baited pots and by diving. Based on two phone diary surveys (2000/2001 and 2001/02), catch estimates from previous mail surveys in 1986/1987, and a phone diary survey undertaken in 2005/06, the recreational catch of western rock lobster for 2007/2008 was estimated at 206t., with 147t. caught by potting, and 59t. caught by diving. Comparative catch estimates for 2006/2007 were 117t. by potting and 57.t by diving. The estimated recreational catch in 2007/2008 was 18.4% above the 2006/2007 catch. The 2007/078 season catch estimate was within the catch prediction confidence limits produced by the model constructed using adjusted mail survey catch estimates. A total of 40,611 licences were sold that permitted fishing for lobsters during some part of the 2007/08 season with an estimated 22,800 (56%) utilised for lobster fishing which was 4% higher than the number of active licences (22,000) for the 2006/2007 season. The average catch taken by active pot and diving fishers was 36 (pots) and 20 (diving). The projected recreational catch for the 2008/2009 season was 265t (de Lestang et al., 2009 pp. 20-21).

Aquaculture

Western rock lobsters are a high value product and the wild caught fishery is considered to be fully exploited with little or no possibility to significantly increase production. The options for western rock lobster aquaculture have been on the agenda for some years.

There are three possibilities with respect to the rock lobster aquaculture: a closed life cycle where broodstock are held, eggs are produced and rock lobsters are grown from larvae through to a market size animal; grow out of wild caught pueruli and post-pueruli; and holding and fattening of legal size commercially caught rock lobster. Of these the collection and growout of pueruli provides the only realistic opportunity to sustainably increase the production of western rock lobster. The highly fecund nature of the species and the high mortality between the puerulus to legal size, suggest that the collection of pueruli may be possible without impacting on the sustainability of the species, so long as the inter-relationship between collection for aquaculture and its impact on commercial wild harvest are managed appropriately (Philips et al. 2003; Department of Fisheries, October 2006; Melville-Smith et al., 2008; Melville-Smith et al., 2009). However given the recent low levels of puerlus settlement this may need to be reviewed.

WCRLF post harvest sector

The Western Rock Lobster Development Association (WRLDA) is the peak body for the post harvest sector of the WCRLF and its members are the key lobster processing companies in WA WRLDA is involved in:

- stimulating the production of western rock lobster while having regard for the conservation and preservation of the fishery;
- standardising and improving packing and processing techniques;
- providing members with the most up to date information on methods of production and costs;
- liaising with the Commonwealth and state government departments;
- facilitating the collective requirements of members in relation to shipping space, loading, transport, procurement of materials used in processing;
- providing members with opportunities to exchange information and ideas relating to the marketing of western rock lobster, and disseminating information relating to the handling of western rock lobster;
- actively promoting western rock lobster in the export market place and developing export trade in western rock lobster; and

- promoting the industry amongst the broader community (Western Rock Lobster Development Association, 2007).

Western rock lobsters are sold and exported as frozen whole raw lobster; frozen lobster tails; fish cooked-chilled or frozen lobster; and live. Live lobsters are primarily exported to Asia, while frozen lobster tails are primarily exported to the United States. Together these two product types make up approximately 60% of the average western rock lobster production. The western rock lobster industry is currently serviced by four main processing companies. These companies purchase live lobsters from the fishermen, and transport them to the processing facilities, with major facilities located in Geraldton and Fremantle, where lobsters are graded, processed and packed for distribution and export. In 2000, the WCRLF became the first fishery in the world to be certified under the Marine Stewardship Council (MSC) standard. All processors (WRLDA members) operate under a formal Chain of Custody Agreement with the MSC, which maintains the integrity of the catch of western rock lobster into the global marketplace, in accordance with MSC criteria (Western Rock Lobster Development Association, 2007).

8.6.2 Environmental, economic and social context

Environmental

Lobsters spawn and hatch their eggs in depths of 40 metres or more. After spending between 9 and 11 months in the open ocean (between 400km. and 1,500 km offshore), the tiny larvae (*phyllosoma*) are carried back toward the coast by currents. On their return to the continental shelf they metamorphose to the next stage (called puerulus smooth, transparent miniature lobsters), and swim across the shelf, aided by wind and waves, to settle mainly on inshore reefs where they moult in seven to fourteen days into juveniles. Each year between November and January large numbers of pale-coloured, recently moulted juveniles (known as ‘whites’) migrate from inshore reefs to the deeper reefs offshore. During this migration run, the lobsters are highly vulnerable to fishing and large catches are taken by the commercial fleet. It is also a good catch period for recreational fishers. Once at deepwater breeding grounds, the lobsters mature and spawn one or two years later. Adult and non-migrating lobsters are known as ‘reds’ and form the catch between February and 30 June each year (Department of Fisheries, December 2004).

In the past the Leeuwin Current strength was a good predictor of the levels of puerulus settlement. The southward-flowing Leeuwin Current affects the spatial distribution of puerulus settlement along the coast. Catches are also dependent upon the environmental conditions. The fishery has been affected by seven years of El Niño or neutral conditions, which has generally resulted in average or below average puerulus settlement, due to the weaker Leeuwin Current strength. Increases in water temperatures over the last 30 to 40 years appear to be affecting some of the biological parameters such as size at maturity and size of migrating lobsters, which will need to be accounted for in future stock assessments. Post-larval (puerulus) recruitment to the fishery is monitored monthly. Annual indices of puerulus settlement for 2006/2007 were below average at all sampling sites. This reflects the negative Southern Oscillation Index, which occurred in 2006. Outcomes from the low 2006/2007 settlement were predicted first to impact on catches during the ‘reds’ of 2009/10 and the ‘whites’ throughout the fishery in 2010/2011. Catches during the 2009/10 season are expected to decline to 8,450 t. The recreational rock lobster catch for the whole fishery is forecast to be 277t. in 2008/2009, and 209t. for 2009/10 (de Lestang et al., 2008 pp. 18, 21). The annual indices of puerulus settlement for 2008/2009 were at record low levels at nearly all sampling sites. This low settlement will impact on catches during the red of 2001/12 and the whites throughout 2012/2013. This low settlement has been unusual in that it occurred during a year during when the Leeuwin current was strong, which may indicate other environmental factors and /or breeding stocks may be contributing to this decline. The possible effect of the Indian Ocean Dipole (IOD), which has had three years (2006-2008) of positive IOD, is being examined, as historically the peurulus settlement has never been above average in a year with a positive IOD (de Lestang et al., 2009 pp. 22, 24).

A symposium *A changing climate: Western Australia in focus* was held on 27 March 2009 in Perth, which provided an opportunity for preliminary research findings to be presented and suggested pathways needed to meet the challenges posed by climate change (Rogers, 2009 p. 3). For the WCRLF it is unclear whether the species’ spawning strategy would adapt to a predicted sustained shift to a weaker Leeuwin Current. Generally, higher settlement of larval lobster, and subsequent adult catch rates in later years, are linked to La Nina conditions. One of the areas with greatest increases in sea surface temperatures, over the last 50 years, occurred off the lower west coast of

Australia, an area dominated by the Leeuwin Current. An increase in frequency of El Nino events also affects the strength of the current, and a trend of increasing salinity have been identified as a key factor associated with changing abundance of a number of key invertebrates and scale fish species. Therefore any changes in the Leeuwin Current can have a significant impact on a number of commercial and recreational fisheries. The WCRLF is the only fishery where larvae are primarily distributed in the area of the influence of the Leeuwin Current and its offshore eddies. Environmental factors such as the current and westerly winter/spring winds significantly affect puerulus settlement of the western rock lobster. The climate change effects may also influence puerulus settlement, catchability, females moulting from setose to non-setose, timing of moults and peak catch rates. These changes and trends may have negative (increasing frequency of El Nino events) or positive (increasing water temperature) implication for the fishery (Ming, 2009 pp. 33-34; Caputi and Lenanton, 2009 pp. 35-36).

Overall, the fishery is unlikely to cause significant trophic (‘food web’) cascade effects, as it is thought that the protected sub-legal-sized lobsters and breeding stock components form a relatively constant, and significant proportion of the biomass, which remains from year to year, and the catch, particularly in inshore areas, is less than the annual variability in biomass due to natural recruitment cycles. However, a recent rock lobster ecological risk assessment considered that, due to the lack of information, the removal of lobster in deep-water regions might have some impact on their surrounding ecosystem, and was subsequently classed as a moderate risk. Habitat effects are considered low, as the legislated design of rock lobster pots; the materials they are made from; and the strict control of replacement pots, minimises ghost fishing problems. A study of human impacts on the marine environments at the Abrolhos Islands estimated that potting might impact less than 0.3% of the surface area of fragile habitat (corals) at the Abrolhos, where fishing is only allowed for three and a half months of the year. Generally, throughout the coastal fishery, rock lobster fishing occurs on sand areas around robust limestone reef habitats, covered with coralline and macro-algae such as kelp. This type of high-energy coastal habitat is regularly subjected to swell and winter storms and is considered highly resistant to damage from rock lobster potting (de Lestang et al., 2009 pp. 22-23).

Economic

The majority of rock lobster production is exported, with the major markets being Hong Kong, Japan and the United States. In 2007/08 beach prices fell by 9% because of the appreciation of the Australian dollar against the US dollar. Although domestic prices have recovered in recent years, they are still about 20% lower in real terms than the peak in 2001/2002 (Pham and Peat, 2009 p. 5). The WCRLF is an important sector of Western Australia’s economy, with the commercial catch from the 2007/2008 season valued ex-vessel at $217 million. Approximately two thirds of Australia’s rock lobster production is from Western Australia, but in recent years production in the State’s rock lobster fishery has declined. In 2006-2007, the volume and value of Western Australia’s rock lobster production fell by 1800t and GVP of $45.5 million. In 2006-2007 the gross value of rock lobster production fell by $17.9 million (4%) to $441 million. Driving this decline was a 12% (1900t.) fall in production. Prices in overseas markets have recently risen because of stronger demand, which is the result of increased promotion and a reduction in supply from competing producers. However, the effect of these higher unit prices on Australian producers’ incomes has been somewhat dampened by the relatively high value of the Australian dollar (Wood et al., 2008 p. 4). The estimated annual commercial value to fishers for the 2007/08 year was $217million. The price that commercial fishers received for the western rock lobster in 2007/08 in all zones of the fishery was an estimated average of $24.30/kg. This was a 14.7% decrease on the $28.50/kg paid in 2006/2007 (de Lestang et al., 2009 p. 23).

Social

Employment is seasonal the fishing season is open for seven and a half months from 15 November to 30 June. A total of 460 vessels and 1,274 people were engaged directly in fishing for rock lobsters in 2007/2008. This equates to one skipper and 1.76 deckhands per vessel, similar to that recorded during the 2006/07 season. During the year, five processing establishments, located in the Perth metropolitan area (3) and Geraldton (2), serviced practically every location where western rock lobster fishing occurred, providing employment in the post harvest sector. Recreational fishing for rock lobsters is also significant, with around 22,000 people taking about 400,000 individual lobsters annually. This fishery sector represents a major recreational activity and provides a social benefit to the Western Australian community (de Lestang et al., 2009 pp. 23).

Recent employment opportunities in the mining and tourism sectors are strong, and this has made it difficult to recruit skippers and deckhands to the fishery, especially during periods of downturn in the fishery.

8.6.3 Management of the WCRLF

A summary of the current operational management arrangements for the WCRLF is outlined in table 8.6.3.

Table 8.6.3: Summary of current operational management for the WCRLF.

Operational management framework	
Legislation	
Commonwealth legislation	Offshore Constitutional Settlement (OCS)
	arrangements between Western Australia and the Commonwealth Government of 1995
	Environment Protection and Biodiversity Conservation Act 1999
W.A. State Legislation	Fisheries Resource Management Act 1994 (FRMA)
	Fisheries Resources Management Regulations 1995
	Fisheries Notices (under the fisheries Act 1905) and Orders (under the FRMA)
Consultation and stakeholder participation	
Stakeholders, forums and mechanisms	Rock lobster Industry Advisory Committee (RLIAC) a statutory committee under legislation (S29 and S30 of the FRMA).
	Eco Scientific Reference Group
	Sea lion interactions Scientific Group
	Recreatioal Fishing Advisory Committee.
	Industry groups WA Fishing Industry Council (WAFIC), other stakeholder groups (Recfishwest, Conservation Council of WA); and general public
	Annual RLIAC coastal tour
	Department and industry meetings
	Western Rock lobster Council
	WCRL Fisherman's Federation.
Co-management arrangements	Commonwealth and W.A. Governments and agencies
	Department of Fisheries
	Rock Lobster Industry Advisory Council (RLAIC)
	Recreational Fishing Advisory Committee (RFAC)
	Western Rock Lobster Council
	Western Australian Fishing Industry Council (WAFIC).

Table 8.6.3 continued: Summary of current operational management for the WCRLF.

Operational management framework	
Management arrangements	
Management plan and regulations	Commercial West Coast Rock Lobster Management Plan 1993 West Coast Rock Lobster Managed Fishery Licence Various Notices and Orders under the Fish Resources Management Act 1994. Recreational Fish Resources Management Act 1994 and subsidiary legislation; Recreational Fishing Licences. WCRLF Recommended management changes for the 2009/10 season (RLIAC May 2009) Rock Lobster management plan 2009/10 Recreational Fishing Guides 2009/10.
Integrated Fisheries Management	Integrated Fisheries Management Government Policy (Department of Fisheries 1 October 2004) A guide to Integrated Fisheries Management (Department of Fisheries 1 October 2006). Integrated Fisheries Management allocation report Western rock lobster resource (Integrated Fisheries Allocation Advisory Committee February 2007)
Industry code of practice	Western Australian Fishing industry Council (WAFIC) Rock lobster industry voluntary code of practice for using and handling bait, bait packaging and rubbish Code of practice for reducing whale entanglements Sea Lion Exclusion Device (SLED) from November 2006 fitted to all pots fished in waters less than 20 m. within 30km. of the three breeding colonies.
Structural adjustments	In the commercial fishery, management initiatives aimed at reducing effort have had the secondary effect of a reduction in fleet size, as vessels purchased additional pot entitlements to improve their economic efficiency.
Compliance and enforcement	For the 2007/08 period targeted compliance operations were conducted for the commercial and recreational fishery sectors. It was estimated the between 8.6t. and 13.4t of illegal rock lobster were consigned (Fletcher and Santoro 2009 p.85).
Fishers reporting requirements	Daily logbooks and monthly returns Voluntary Research Log books.

Table 8.6.3 continued: Summary of current operational management for the WCRLF.

Operational management framework	
Management processes and measures	
Inputs/outputs/technical measures	Commercial fisheries The fishery is managed using a total allowable effort (TAE) system and associated input controls. The number of pots licensed for the fishery with a proportional usage rate, creates the TAE in pot days. Input controls: limited entry; maximum number of pot entitlements for fishery; restrictions on pots; spatial and seasonal restrictions; and restriction on pots being pulled only during specific daylight hours. Output controls: the protection of breeding females and minimum legal size of rock lobster; gear controls, such as escape gaps, size of pots. Recreational fishing: Requires a licence, and are managed under fisheries regulations which impose a mix of input and output controls. (2 pots per licence holder; gear specific size requirements and escapement gaps; bag and boat limits; night time fishing banned. Eegulation on minimum size limits, protection breeding females, and maximum size of females the same as those for commercial fishers. A Sea Lion Exclusion Devices (SLEDS) must be fitted in all rock lobster pots (commercial and recreational) used in the identified SLED zone.
Allocation of user rights	Total allowable effort (TAE) based on input controls of number of pots licensed for the fishery with a proportional usage rate, creates the TAE in pot days. Unitisation and transferability provisions through individually transferable effort (ITE) management system. Allocations are over total area of the fishery, with proportional allocations to recreational at 5% and commercial 95% of total catch. Proposed approach to managing allocations, using the five year moving average as a performance indicator. For Customary fishing the initial allocation should be one tonne as outlined in the Integrated Fisheries Management initiative.
Stock assessment	Annual stock assessments. Stock sustainability and forecasting future catch levels, using fishery independent monitoring (monthly) of puerulus settlement and breeding stock levels, industry catch and effort records from fishers and processors, data from the voluntary log book scheme.

Table 8.6.3 continued: Summary of current operational management for the WCRLF.

Operational management framework	
Quotas and TACs	The development of a business case for a quota management system is being undertaken and discussed by RLIAC, but is not under consideration for 2009/10 season.
New management measures	WCRLF recommendations for the 2009/10 season (FRLIAC July 2009) Management arrangement for commercial WCRLF for 2009/10 season announced by Minister 24 September 2009 with limit catch set 5,500t. New management arrangements for recreational fishing (Department of Fisheries October 2009).
Objectives/indicators/decision rules	A draft paper outlining new 'decision rules' for the West Coast Rock Lobster Fishery was released in 2008. Key proposals contained in this paper are the addition of harvest rates and allowing for uncertainty into the decision rules framework. The inclusion of these two proposals will make the decision rules framework more robust. It also means that management decisions will be more consistent, predictable and transparent. The proposed framework is consistent with the recently released Harvest Strategy Policy for Commonwealth fisheries (Fletcher and Santoro 2008 p. 21).
Spatial and temporal management	Commercial fisheries are managed within three major zones (Zones A, B and C) The season is open from 15 November to 30 June annually, with the Abrolhos Islands zone operating from 15 March to 30 June. The recreational fishery operates on a statewide basis and subject to the same temporal management as the commercial sector.
Environmental considerations	
Bycatch (includes TEPs, habitats, ecosystems)	Octopus and deep sea crabs see Environmental Strategy 2002-2006; Ecological Risk Assessment 2007; and the Rock Lobster Environmental Management Strategy July 2002 - June 2006.
Economic considerations	
Economic	ESD Policy for the implementation of ESD for fisheries and aquaculture in W.A. (Department Fisheries March 2002). IFM Policy (Department of Fisheries October 2004) supports ESD principles. To be included in he next ESD reports
Social considerations	
Social	ESD Policy for the implementation of ESD for fisheries and aquaculture in W.A. (Department Fisheries March 2002). IFM Policy (Department of Fisheries October 2004) supports ESD principles To be included in the next ESD reports.

Table 8.6.3 continued: Summary of current operational management for the WCRLF.

Operational management framework	
Management assessments	
Review of management options	Review of the draft paper proposed quota setting for the West Coast Rock Lobster managed fishery (Morgan, February 2009); which should be read in conjunction with the Proposed quota settings for the West Coast Rock Lobster managed Fishery (RLIAC December 2008), and An analysis of maximum economic yield in the Western Rock Lobster Fishery (Reid, February 2009).
Strategic assessments under the EPBC Act	Undertaken in 2001 and 2007 and approved by the Minister. The next assessment is due in 2012.
Risk assessment	ERA completed 2005 but only the environmental aspects, a new ERA was completed 2007
Marine Stewardship Council (MSC) accreditation	Accredited in 2001 and 2006.
Fishery performance assessment	
Department of Fisheries reporting requirements	Annual State of the Fisheries Reports Annual Report to Parliament
WCRLF ESD report	A major element of WA ESD policy was the requirement for reporting on the progress of each commercial fishery against the major ESD objectives by the end of 2003. In the 2005 ESD reports only reported on the environmental and governance dimensions,, the economic and social will be included in the next report.
Independent assessments	Marine Stewardship Council accreditation March 2000 and December 2006, and annual surveillance reports.
Research and data	
Research plan	Research and development plan 2008-09 (Department of Fisheries February 2009) West Coast Lobster effects of fishing research plan (Department of Fisheries December 2006). Research outlined in annual State of the fisheries reports
Monitoring and independent observer program	Fishery dependent and independent systems, long time series. Processor returns, onboard observers for commercial fishing, and surveys of recreational fishing.

Key management and assessment documents for the WCRLF (notices and announcements; the sectors; management of the fishery and its sectors; consultation; assessment; and publications) can be found on the Department of Fisheries web page (Department of Fisheries, January 2010).

8.7 Recent management changes and addressing issues in the WCRLF

Some of the most recent and significant management changes applied to all WA managed fisheries (and applied in the WCRLF) include the Integrated Fisheries Management (IFM) and the EBFM framework; and a review of the MAC structure is also being undertaken. There are also ongoing discussions regarding the management options for the WCRLF.

8.7.1 Department of Fisheries management changes

Integrated Fisheries Management (IMF) Framework and EBFM

As outlined above Integrated Fisheries Management (IFM) aims to address the issue of how fish resources can be best shared between competing users (commercial, recreational, charter, and Indigenous fishers), and managing the take by these sectors within the broader context of ESD. The IFM Branch consists of two bioregionally-based teams, a state-wide fisheries policy team and an IFM team. The state-wide Fisheries Policy team deals with strategic fisheries management issues that apply more broadly across the bioregions. The IFM team deals with those resources for which the Government has explicit policies to formally determine and manage resource shares. Within the IFM policy development of a market-based re-allocation framework is considered desirable, as it would allow allocations to vary in response to sectoral and community needs and values. To develop this element of the IFM, the DoF commenced a Fisheries Research and Development Corporation (FRDC) funded project on re-allocation frameworks and mechanisms in January 2008 (Department of Fisheries, 2009 pp. 36-37). The report and discussion paper *Potential reallocation mechanisms for the transfer and/or adjustment of catch shares between sectors with application to the Western and South Australian rock lobster fisheries* was released in February 2010. Public comments regarding the discussion paper have been sought and the closing date for submissions was Friday 23 April 2010. Once public comments have been considered, a final report will be presented to the Minister (Reid, January 2010).

Management Advisory Committees (MACs)

Industry consultation on fisheries management is undertaken through the Management Advisory Committees (MACs) for each fishery. A review of consultation structures including MACs was commenced during 2008/2009. Consultation reform is likely to see an end to the system of MACs, which have provided advice to the Minister on fisheries management issues since 1995. Instead, the DoF will be the primary source of advice for the Minister on ecological, economic and social considerations relating to fish stocks. Peak bodies, notably the Western Australian Fishing Industry Council and Recfishwest, will provide important industry/stakeholder representation, along with a state-wide fisheries strategy group. The department is also holding discussions with Regional Recreational Fishing Advisory Committees (RRFACs) and Recfishwest, regarding the former being replaced by a new regional representation model (Department of Fisheries, 2009 p. 5).

The Consultation Working Group has developed the proposed model and recommendations in the context of the linkages between consultation reform and the development of new funding arrangements for the management of fishing activity in WA. The key changes are the separation of strategic advice (to be provided by the Aquatic Advisory Committee) and management advice (to be provided by fishing sector representatives, tasked working groups and other stakeholder input) to the DoF who in turn would provide advice to the Minister of Fisheries. The changes would also require amendments to the Fish Resources Management Act 1994. The Working Group recommended that July-December 2009 would be a transition period during which the details of the model were to be developed; and January-June 2010 funding arrangements and legislation were to be amended; with full implementation by 1 July 2010, and a review of the new arrangements within three years of implementation (Consultation Working Group, July 2009). The report and recommendations for a funding model have alos been provided (Funding Working Group, July 2009).

Review of management options in the WCRLF

In March 2002 the State Government of WA initiated a review of the WCRL management system. The purpose of the review was to present alternative options for managing the fishery and to compare the current fishing effort control system to a more flexible one. It also considered two types of individually transferable quota (ITQ) management systems, one with the current effort controls and the other without or with reduced effort controls. The review was undertaken over a three year period and the final reports were published in January 2006. The four volume report included an overview of bio-economic, sociological and comparative analysis (Department of Fisheries, January 2006); a bio-economic evaluation of management options for the West Coast Rock Lobster Fishery (Economic Research Associates Pty Ltd, January 2006); a social assessment of the coastal communities hosting the western rock lobster fishing fleet (Huddleston, January 2006); and an assessment of how quota management systems work in rock lobster fisheries (Bray et al., January 2006). The outcomes of the review process highlighted that the industry preferred to maintain the input control system, rather than moving to a quota management system. Although it was made clear that staying with input controls did not mean there would be no changes to the management system, and adjustments to the level of effort in the fishery would be required. In economic terms the WCRLF was also facing economic challenges and unless the industry could improve its efficiency or value of its product this was likely to impact on the long-term profitability of the fishery (Western Rock Lobster Council Inc, July 2007 pp. 4-5).

Discussions continued and the Minister requested that the Rock Lobster Industry Advisory Committee (RLIAC) prepare a business case for a quota management system (QMS). RLIAC convened a working group to prepare a business case with the overall aim of defining a workable QMS rather than addressing comparisons with the current management system. Findings were presented in the report *Review of the draft paper proposed quota setting for the West Coast Rock Lobster managed fishery* (Morgan, February 2009); which should be read in conjunction with *Proposed quota settings for the West Coast Rock Lobster managed Fishery* (Rock Lobster Industry Advisory Committee, December 2008), and *An analysis of maximum economic yield in the Western Rock Lobster Fishery* (Reid, February 2009). In summary, the findings identified a number of significant issues. There was no statement of the objectives of the proposed QMS or any consideration of whether the proposed QMS was the best way of achieving the (unstated) objectives. From a stock sustainability viewpoint the proposed quota setting methodology and the resultant quotas would retain exploitation rates at approximately the current level. The proposed quota setting is potentially subject to lobbying and interference and therefore did not provide the certainty in outcomes from the processes that would result in industry or investor confidence, and this would impact negatively on asset values of the ITQs. From a profit maximisation viewpoint, the suggested approach was conservative in that it proposed a very slow pace of introducing the elements of a QMS, while retaining many of the existing input controls in place. Therefore the economic and financial benefits that often flow from an ITQ system were unlikely to be realised until further reforms were implemented. Under these conditions there was a risk that operators will not support the proposed QMS, as there would not be any perceived benefits to their businesses (Morgan, February 2009 p. 1).

There have been further discussions regarding how the fishery would be best managed under a Quota Management System (QMS) or the continuation of the current Input Control Management System (ICMS). Proponents for quota argued that QMS would provide the best management framework to optimise the fisheries' economic performance. Supporters of the existing framework believed that ICM could achieve similar economic and biological objectives without the transitional costs of introducing QMS. Since then, as part of the ongoing process, the Minister for Fisheries requested advice from RLIAC on the best quota management system for the WCRLF, by June 2009. To assist RLIAC in preparing its final advice to the Minister, regarding the most appropriate long-term management framework for the fishery, the committee commissioned a panel of independent fisheries management experts to develop an optimal quota management system specifically designed for the WCRLF; and to develop an optimal ICMS for the fishery, to enable a rational comparison between the two types of management frameworks. Outcomes from the expert panel are contained in the following two reports *A quota management system for the Western Rock Lobster Fishery* (Morgan et al., June 2009a); and *An input control management system for the Western Rock Lobster Fishery* (Morgan et al., June 2009b).

When comparing the two frameworks, both had advantages over the current management system, but overall there were both advantages and disadvantages to achieving the management objectives by either QMS or ICMS, which were addressed in detail in the QMS report. The expert panel, in considering the key features of an optimised ICMS and QMS (and notwithstanding the considerable transition issues discussed in the ICMS report), were of the view that on balance a QMS offered a more appropriate and effective way of achieving the defined management objectives in the medium to long-term in a way that provided and promoted efficiency in the industry through greatly increased flexibility to respond to markets (Morgan et al. June 2009a; and Morgan et al., June 2009b). Should a decision be made to introduce a new management framework for the fishery, RLIAC's view was that it would take at least two years to implement. In the interim, the WCRLF should continue to be managed under the existing input control management system.

8.7.2 Addressing issues in the WCRLF

Some key issues and management responses as they relate to the WCRLF will be discussed. These include: harvest strategies; Marine Stewardship Council accreditation; deepwater ecosystems; structural adjustments; discarding, bycatch and protected species.

Harvest strategies

Due to low puerulus settlement and a reduction in the numbers of lobsters available to the fishery there have been significant management changes in the WCRLF. Prior to the start of the 2005/2006 season the DoF introduced a new management package for the fishery, recognising the need to manage each zone separately because of the different levels of breeding stock within each zone of the fishery. In Zone A the exploitation rate and breeding stock index were above target levels; Zone B the exploitation rate and breeding stock index were trending downwards (research advice outlined a 15% effort reduction was needed to address the declining trend); Zone C the exploitation and breeding stock index were above the target levels, but given the poor recruitment occurring in the zone, this would be likely to have a negative impact on the breeding stock index in the following years (advice was that industry should aim for a 5% reduction in an effort to help offset the impact of poor recruitment years on the breeding stock) (Western Rock Lobster Council Inc, July 2007 p. 4).

The RLIAC recommendations regarding management changes for the 2008/09 season were aimed at addressing the sustainability and economic objectives of the fishery for the next three years, to be monitored annually and reviewed prior to the 2010/11 season. For all zones effort reduction was recommended, with the objectives of reducing pot density saturation by reducing the number of pots to maximise overall profitability of the fishery; reduce the harvest rate to below the indicative level; ensure equity between the zones was maintained with the introduction of the new management package; and introduce changes that reduce short-term and longer term costs and have a minimum negative impact on the overall profitability of the fishery (Rock Lobster Industry Advisory Committee, May 2008 pp. 3-5).

In providing advice to the Minister for the 2009/10 season RLIAC noted, although the measures adopted in 2008-2009 appeared to have been successful, RLIAC members were concerned that model projections suggested if puerulus settlement remained at current low levels, breeding stock and egg production in all zones of the fishery would continue to decline in the absence of management actions. As the cause of the low settlement in recent years was unknown, RLIAC was of the view that a conservative management approach, which took into account the worst case scenario, was required to protect the breeding stock. RLIAC recommended measures that would achieve reduction in commercial fishing effort on 2008-2009 levels in all zones as follows: 40% in Zone A; 30% in Zone B; and 44% in Zone C. Action should also be taken to restrict recreational take to its historical proportion of the total catch at 3-4% rather than being permitted to increase to the sectors' 5% allocation (Rock Lobster Industry Advisory Committee, 6 July 2009).

Following the advice from the RLIAC and the DoF (and with the support of the Western Rock Lobster Council), on 24 September 2009 the Minister announced the management arrangements for the commercial WCRLF for the 2009/2010 fishing season. This included reductions in pot usage; restriction on the days when fishing will be allowed; minimum legal length for lobsters; changes to escape gaps; and Big Bank will remain closed. These changes are intended to achieve an overall catch of 5,500t (with an expected range between 4,950t. to 6,050 t.). Separate target catches will apply in each of the fishing zones for the first and second halves of the season. Poor puerulus settlement means availability of lobsters will be significantly reduced on the 2010/2011 and 2011/2012 seasons. By setting the 2009/2010 season target of 5,500t., it should be possible to maintain similar catch rates for the following two fishing seasons, thereby ensuring a more consistent catch, and improve economic returns. The catch was to be monitored on a weekly basis during the season, with a formal review scheduled for January 2010. If the catch level in any of the zones differs significantly, or looks like varying from its target, adaptive management action could be taken. A set of business rules was developed to help guide decision-making for the 2009/10 season, if management intervention was required, to ensure catch remained within its limits. As well as the management changes in the commercial fishery, new management measures (reduced bag and boat limits and a possession limit) were introduced for recreational western rock lobster fishing in the West Coast Bioregion. (Government of Western Australia, 24 September 2009; Department of Fisheries December, 2009). To keep industry informed of the changes the DoF published a series of monthly newsletters from August to December 2009. Further changes to the management arrangements for the fishery in all zones have been required during January 2010 (Department of Fisheries, January 2010).

The DoF is reviewing its methodology for estimating the breeding stock, which includes further development of the biological model at a finer-spatial scale; oceanographic modelling aimed at evaluating the effect of breeding stock in different regions, and environmental factors on puerulus settlement; expanding the current juvenile abundance sampling program to evaluate settlement in shallow and deep water; conducting a research risk assessment workshop on factors affecting puerulus settlement; and assessing the fishing effort required to achieve the maximum economic yield for the fishery (Department of Fisheries, 13 February 2009 Letter Ref:15/09; Department of Fisheries, February 2009 pp. 4-6).

The Department of Fisheries advised stakeholders that it had been working co-operatively with other research organisations to investigate the cause of recent low puerulus settlement. This included holding the *Western Rock Lobster Low Puerulus Risk Assessment Workshop* on 1st and 2nd April 2009 (Brown, September 2009). In summary, the three most plausible causes identified were: one, both short and long-term environmental changes (physical and biological) are occurring in the eastern Indian Ocean, where for the first time a positive Indian Ocean Dipole coincided with a La Nina event in 2008. Two, a decline in a particular part or parts of the breeding stock. There is some evidence that breeding stock levels may have fallen below the 1980s threshold level and are close to limit reference point. The decline in Big Bank, northern Abrolhos and the coastal deepwater areas in Zone B are of particular concern, as these areas could be more important in producing successful settlement. There are also concerns in other deepwater areas in Zone A and Zone C (north of Lancelin). Three, a combination of both, poor environmental conditions, and a decline in lobster breeding stock. Under these circumstance the reduction in fishing effort/exploitation should continue into future seasons until breeding stocks are shown to be at a safe level (which may require higher target and threshold levels than were previously considered safe). Further research projects (funded by FRDC) are being undertaken to investigate various aspects of the possible causes and factors associated with the low peurulus settlements of 2007/2008 and 2008/2009 (Brown, September 2009 pp. 1-10, 45-46; Department of Fisheries, October 2009 p.39).

Marine Stewardship Council accreditation

The western rock lobster was one of the first fisheries in the world to be certified as ecologically sustainable by the Marine Stewardship Council (MSC). The fishery was certified by Scientific Certification Systems (SCS), Inc. in 2000 following a full assessment of the fishery using the MSC standards and certification methods. The fishery completed a recertification assessment in 2006 (Scientific Certification Systems Inc, 12 December 2006). SCS found minor non-conformances that needed to be addressed by the next annual audit. As a result of the second surveillance audit released on 3 July 2009, SCS had two main concerns regarding the fishery. One, the current long standing predictive model for puerulus settlement (using sea temperature and wind conditions) which had previously provided a good explanation of the variations in settlement did not adequately explain the recent low settlements (particularly in 2008/2009). Two, the breeding stock may have declined to a point where it was impairing recruitment. The uncertainties regarding these factors represented a high risk to the fishery and to the continued MSC certification of the fishery. SCS was of the opinion that there was sufficient evidence to require a limited reassessment of the West Coast Rock Lobster Fishery under Principle 1 (Stock Status and Harvest Strategy). Therefore, SCS planned a special audit to take place in September 2009. This special audit would consist of the expedited 2010 annual surveillance (Scientific Certification Systems Inc, 3 July 2009 p. 4). The outcomes from the 2009 special audit, including reassessment under Principle 1 found that although the fishery continued to meet the MSC standard, endorsement by MSC however, is subject to meeting new and existing non-confirming conditions as outlined in the report (Scientific Certification Systems Inc, December 2009).

Deepwater ecosystems

The Rock Lobster Industry Advisory Committee (RLIAC) established the Ecological Effects of Fishing Scientific Reference Group (EcoSRG). This group is responsible for providing independent ecological advice to ensure the western rock lobster resource is managed in a manner that is consistent with the national principles of ESD and EBFM. The EcoSRG held the view that there was a general lack of knowledge or information on the interaction of the WCRLF with the deepwater ecosystems; and as EcoSRG was not able to determine the impact on the ecosystems of removing lobsters form deep-water habitats, this should be a priority focus for research. There were three key external drivers that created the need to develop and implement a research plan for the WCRL. These were the Marine Stewardship Council assessment; the EPBC strategic fisheries assessment; and the Jurien Bay Marine Park (Ecological Effects of Fishing Scientific Reference Group, December 2006 pp. 3-5). The process of obtaining MSC certification involved a number of key components, two of which involved the development and implementation of an Ecological Risk Assessment (ERA) and an Environmental Management Strategy (EMS). The results from the 2007 ERA ranked the risk to deep water communities (Central west coast, and the Kalbarri-Big Bank) as moderate due to lack of data. Commitments have been made to address the data gaps in deep water ecology through research and the risks will be reassessed when the results of the research activities become available (Stoklosa, 2007 pp. 20-24). A FRDC funded project to examine the effects of western rock lobster fishing on the deep-water ecosystem off the west coast of Western Australia provided critical baseline data on the relationships between the abundance and size distributions of rock lobster, and the different benthic habitats located in deeper waters, plus preliminary data on diets and the trophic role of rock lobster within these depths (Bellchambers, 2010; Department of Fisheries, October 2009 p.38). Further ecological research in deep waters will be based on comparing fished and unfished areas using spatialclosures The aims of this project are to enable any impacts of lobster fishing on deepwater ecosystems to be quantified (Department of Fisheries, October 2009 pp. 38).

Structural adjustment

In the commercial fishery, management initiatives aimed at reducing effort have had the secondary effect of a reduction in fleet size, as vessels purchased additional pot entitlements to improve their economic efficiency. In 2006/07 a fleet of 491 vessels fished for lobster, with 128 in A Zone, 111 in B Zone and 252 in C Zone (compared to the 500 active boats in 2005/06), which was a reduction of 1.8% (de Lestang et al., 2008 pp. 15, 17, 21). In 2007/08 a fleet of 460 (a reduction of 6.3% on the previous year) vessels fished for lobster, with 126 in Zone A, 106 in Zone B, and 228 in Zone C. The nominal fishing effort was 7.9 million pot lifts in 2007/08 (4.5% lower than 8.3 million pot lifts for 2006/2007 and the lowest level since 1970s). This decline in nominal pot lifts is due in part to the sustainability package adopted in the 2005/2006 season and reduced fishing due to lower catch rates and increased costs. The 2007/2008 nominal effort for A, B and C Zones was 1.1, 2.7 and 4.2 million pot lifts respectively, which was 8.1%, 3.6% and 4.2% lower than the previous season's pot lifts. For the recreational fishery a total of 40,611 licenses were sold that permitted fishing for lobsters during some part of the 2007/2008 season, with an estimated 22,800 (56%) utilised. Sales of licences and utilisation rates are higher in years of good recruitment to the fishery. For 2007/08 season the average rates of usage by active recreational pot and diving fishers were 14 and 6 days respectively; and average catch by active pot and diving fishers was 36 and 20 lobsters respectively (de Lestang et al., 2009 p. 21).

Discarding and bycatch and protected species

Bycatch for non-retained species and protected species interactions are considered a low risk in the WCRLF. Fishery-independent monitoring on commercial vessels records the catch rates of fish and invertebrate bycatch species caught during normal rock lobster fishing operations. Approximately 87,435 fish and invertebrates (other than rock lobster and octopus) were captured for the 2006/2007 fishing season of which most were released. Previously, the WCRLF interacted with the Australian sea lion, resulting in the accidental drowning of a small number of sea lion pups in rock lobster pots. Incidents were restricted to shallow waters (< 20 m) and to areas within 30 km of the mainland sea lion breeding colonies on the mid-west coast. In order to eliminate these accidental drownings, from 15 November 2006 all pots fished in waters less than 20 metres within approximately 30 km of the three breeding colonies (i.e. just north of Freshwater Point to just south of Wedge Island) were fitted with an approved Sea Lion Exclusion Device (SLED). Video trials have indicated this device does stop sea lion pups from entering lobsters pots and drowning. Monitoring of commercial pots in the SLED zone in 2006/07 showed that over 95% of pots checked had an approved SLED fitted (de Lestang et al., 2008 pp.18-20; de Lestang et al., 2009 pp.22-23).

Turtle deaths as a direct result of interaction with the lobster fishery are very rare. Of the six turtle species that occur within the waters of the western rock lobster fishery, the entanglement of leatherback turtles was still rated as a low risk. In 2005/2006, no leatherback turtles were reported to have been entangled in lobster fishing gear. This incident rate is below the historical range of between two and five entanglements per season over the preceding five seasons. There are occasional reports of a whale becoming entangled with pot ropes. The humpback whale is the predominant species that interacts with the WCRLF, during its northward migration to the North West Shelf breeding grounds in June to August each year. Owing to the fishery's closed season, there is a limited period for interaction, but with the increasing population of whales, more interactions are likely to occur in the future. Interactions are reported by industry to the Department of Environment and Conservation (DEC) and a specialist team is used to disentangle the animal, with a very high success rate. The western rock lobster fishing industry has developed a code of practice to minimise the interaction with whales in conjunction with DEC and SeaNet. The environmental management strategy adopted for the WCRLF requires monitoring of, and attempts to, minimise accidental interaction with these species wherever practicable. For the period 1989 to 2005, commercial lobster fishing has resulted in zero to four whale/dolphin interactions per season. During the 2006/2007 lobster season, one whale was recorded as becoming entangled and subsequently successfully disentangled (de Lestang et al., 2008 p. 20; de Lestang et al., 2009 p. 22).

8.8 Discussion

The major drivers of change for fisheries in the last ten years have been public and stakeholder expectations; and national policy and policy initiatives, which have set the parameters for fisheries management. As described in this Chapter the introduction of ESD and EBFM, has resulted in a number of institutional changes in the management framework of AFMA and in managing Commonwealth fisheries; and likewise for the Department of Fisheries in managing Western Australian fisheries. Both agencies have a legislative requirement and institutional role in managing fisheries under ESD and EBFM principles, and responsibility for demonstrating this in practice. The long-term policy strategies which have been developed to facilitate the implementation of ESD and EBFM will require regular review as the environmental, economic and social conditions and circumstances will continue to change, and these changes may necessitate policy and management amendments; as well as monitoring that the outcomes are meeting the stated objectives.

AFMA is responsible for commercial wild caught fisheries, whereas DoF is responsible for commercial wild caught, recreational, charter and indigenous fisheries sectors, and aquaculture. Because of these differences the respective strategic and operational management frameworks are not directly comparable, but they do demonstrate similarities in approach as outlined in Figure 8.8. The key management changes in Commonwealth and state managed fisheries as discussed in Chapter 7, set the parameters for strategic and operational fisheries management at the individual fisheries level. In this Chapter the systems model (as developed in Chapters 3, 4 and 5) was applied to identify how ESD and EBFM principles and requirements have been incorporated into the strategic and operational management arrangements at the fishery agency level and the individual fishery level, through two case studies. In this Chapter the strategic management practices in AFMA and WA DoF fisheries agencies were identified; and implementation of operational management processes and measures were identified for two case study fisheries, the Commonwealth managed SESSF and the WA DoF managed WCRLF.

Fisheries agency	AFMA a statutory Commission	Department of Fisheries W.A. fisheries agency
Management roles and responsibilities	Commonwealth commercial wild caught fisheries and ecosystem sustainability under ESD and EBFM principles	Commercial wild caught, recreational, charter and indigenous fisheries sectors and aquaculture and ecosystem sustainability under ESD and EBFM principles
Consultation participatory decision making	MACs Co-management arrangments Stakeholder consultation and communication	MACs Co-management arrangments Stakeholder consultation and communication
Strategic management framework		
Policy	Minister's statutory Direction AFMAs response to the Direction Harvest Strategy Policy and guidelines Ecological Risk Management (ERM) framework Bycatch and discarding Policy	Policy for the implementation of ESD EBFM framwork Integrated Fisheries Management Policy Bycatch and discarding Policy
Operational management framework		
Management arrangements processes and measures	Inputs/outputs/technical measures Harvest strategies Ecological risk assessment Bycatch and discarding work plans Spatial and temporal management	Inputs/outputs/technical measures Harvest strategies Ecological risk assessment Bycatch and discarding plans Spatial and temporal management
Management and fishery performance assessments	Strategic assessments under EPBC Act 1999 Independent assessment AFMAs annual report to parliament	Strategic assessments under EPBC Act 1999 Independent assessment Marine Stewardship Council DoFs annual state of fisheries report and annual report to parliament
Research	AFMA's Strategic Research Plan	DoFs Strategic Research Plan
Monitoring and observer prgram	Fishery dependent and independant data Monitoring and observer data	Fishery dependent and independant data Monitoring and observer data

Figure 8.8.1: Strategic and operational management framework.

8.8.1 Strategic management framework: Australian Fisheries Management Authority and Western Australia Department of Fisheries

The strategic five year plans for both AFMA and DoF provide a basis for forward planning, but given some of the environmental issues such as climate change and stock rebuilding initiatives, these and other issues will require longer planning frameworks, from ten years and up to 25 years, or more in some cases. Consultation mechanisms have been developed for stakeholder participation and decision-making by AFMA and DoF. These have been formalised through the MACs and consultation with industry and stakeholder peak groups, as well as the opportunity for general public comment and input. AFMA and DoF however, are currently reviewing the MAC model and how advice is provided. Some form of co-management has been a feature of Australian fisheries and more recently there has been an interest in further developing a more delegated co-management approach in selected Commonwealth fisheries, once the necessary conditions are in place. Compliance forms part of the management framework aimed at providing incentives for compliance with management arrangements, and levying penalties if necessary. Research, monitoring, and independent observer programs, underpins fisheries management and decision-making.

In response to the Ministerial Direction, and the requirements of fisheries strategic assessments under the EPBC Act, AFMA has developed a number of management initiatives. The Ecological Risk Management (ERM) framework assesses the risks (impacts to target, byproduct, bycatch and TEP species; and habitats and communities), and management response in addressing issues and impacts. The ERM model is a tool for setting minimum standards for fisheries that should be applied to all Commonwealth fisheries. The application of the precautionary principle (specifically in adoption of risk standards for exceeding reference points) has been achieved through a Harvest Strategy Policy (HSP) which is to be applied to all Commonwealth fisheries. The development of sustainable harvest strategies for target species includes decision rules; global quotas that include discards, and in some cases state catches; and quotas which allow for stock rebuilding and minimise the potential for over-fishing. Initiatives for managing and minimising impacts on non-target species and the wider ecosystems components include bycatch and discarding workplans. An accredited fisheries management plan and an ecological risk assessment (using the Ecological Risk Assessment for Commonwealth Fisheries (EREAF) approach (developed by AFMA and CSIRO) are requirements for fisheries undertaking strategic assessments under the EPBC Act, in demonstrating that ecological sustainability objectives are being met.

Similarly, DoF has developed an ESD Policy that incorporates EBFM. The EBFM framework is a risk based management approach that asses the risks and impact to environmental assets (ecosystem structure and biodiversity; capture fish species; protected species interactions; benthic habitats; and the general environment). The Integrated Fisheries Management (IFM) initiative aims to manage fisheries in a manner that shares the overall catch between all fisheries sectors in a sustainable manner, by accounting for total mortality including bycatch and mortality of released fish. The development of harvest strategies includes allowing for uncertainty in the decision rules framework which is consistent with the Commonwealth HSP. This incorporates pre-determined actions which are invoked if a group's catch increases above its allocation, so that future sustainability is not compromised. The DoF operates within the principles of ESD and this approach includes managing bycatch and interactions with protected species, and any potential indirect impacts of fishing and aquaculture activities on the broader ecosystem. An accredited fisheries management plan and an ecological risk assessment (as developed under the national ESD reporting framework) are requirements for the fisheries undertaking a strategic assessment, aimed at identifying the risks that fishing poses to ecological sustainability of target and other species, and critical habitats.

8.8.2 Operational management: the two cases studies

Prior to the introduction of ESD and EBFM existing fishery processes and measures were already in place for commercial target species. Since then the importance of other species, habitats, communities, and ecosystems have been acknowledged, and the wider environmental focus has had to be explicitly accounted for in operational management arrangements, and in practice. The management processes and measures, as expected, are different for the two case study fisheries. As they are in response to managing a multi-species, multi gear and multi-sector fishery (SESSF) versus a single species and method fishery (WCRLF) fishery, but as identfied the operational management approaches are complementary. Sustainable stocks and harvest strategies are a feature of both fisheries management and have been applied at the operational level. However, for the harvest strategies to be successful it is necessary to manage effort creep (as a result of the development and uptake of new technology), and this has been a problem for both fisheries, and was a factor in the need for the recent structural adjustments for the SESSF and in the WCRLF. Bycatch, discarding and interactions with protected species have been an issue in the past, but are now being more actively managed through risk management strategies and operational mitigation measures. The use of spatial and temporal management measures have a long history in fisheries management generally, and are currently applied to the management of both the SESSF and the

WCRLF. The purpose of the management and fishery performance assessments, are to demonstrate that the fisheries are being managed according to the regulatory requirements and the stated management objectives. Both SESSF and the WCRL fisheries have been accredited as Wildlife Trade Operation fisheries, as part of the strategic assessment processes under the *EBPC Act 1999*, and the WCRLF has also been accredited under the Marine Stewardship Council (MSC) accreditation scheme. AFMA reports to stakeholders through the annual state of the fisheries report to parliament; and DoF through annual state of fisheries reports, and annual reports to the WA parliament. Research and data underpin the strategic and operational fishery management in both agencies. It should be noted, however, that both the SESSF and the WCRLF are high value fisheries which have been well researched and have long-term data sets. Even under these more ideal conditions there are still information gaps and issues relating to a lack of standardised metrics when collecting and collating data.

Taking a broad view the vision, goals and objectives of both agencies are in accord, in terms of managing fisheries and the broader ecosystem dimensions on a sustainable basis, and in developing standards for operational management. The incorporation of ESD and EBFM principles into strategic and operational management and implementation at the fishery level has moved from planning to implementation stage, at least for the SESSF and WCRLF. The two case studies were used to discuss and demonstrate how the respective policy initiatives and strategic and operational management are being implemented in practice. In these fisheries, the development of fisheries management objectives and performance indicators and performance reporting is beginning to allow a more adaptive management response to addressing the issues.

As outlined above, currently strategic and operational fisheries management is focused on environmental sustainability, with very little consideration or action requirements for the economic and social dimensions. Under these circumstances ESD and EBFM in total is only partially implemented and is therefore limited and incomplete. This Chapter was limited to two case studies. In order to assess how far Australia has moved towards an ESD and EBFM approach in practice, across all fisheries will, require further evaluation and assessment, as discussed in Chapter 7. Fisheries are managed as discrete units and currently it is difficult to assess how complementary individual fisheries management measures are between Commonwealth and state managed fisheries (particularly, in managing cumulative impacts within and across fisheries jurisdictions). There are still questions for policy and strategic management, such as how the impacts of climate change are likely to affect species and ecosystems, what this will mean for current operational fisheries management, and how this might be managed, particularly with regard to resilience of ecosystems and human systems. Although much has been achieved, until these aspects are addressed, there is still further work to be undertaken before Australia can claim to have an integrated strategic management approach, and to have moved towards the full implementation of EBFM.

8.9 Summary

The purpose of this Chapter was to identify how Australian fishery management agencies are incorporating ESD and EBFM principles into their institutional and management arrangements and implementing them in practice, at the fishery level. As discussed in Chapter 7, Australian fisheries are diverse and operate under different management regimes and may also be at different stages in their application of ESD and EBFM methods and uptake of tools. EBFM is an ongoing and evolving approach to resource management, and while there is a need for improvement there are already effective procedures and processes in place that support ESD and EBFM in Australia, as demonstrated through the two cases studies.

In the last 10 years Australian fisheries management has undergone profound policy changes and this in turn has resulted in changes for strategic and operational management at the fishery level. There are a number of aspects, however, which will require further work, so as to move from partial implementation towards a more fully implemented EBFM approach. These include the habitat and ecosystem components of the environmental dimension; further development of the economic and social dimensions; and a more integrated approach for all three dimensions at the institutional, operational and performance assessment levels.

Fisheries are located within diverse and complex ecosystem and human systems. The scope of fisheries management has widened to include the environmental, economic and social dimensions. Management is also required to understand a wide range of institutional arrangements (legislative framework and policy initiatives), and how these impact upon, and relate to the fishery (Cunningham, 2005). Fisheries managers are required to take into account the state of the stock (biological objectives) and to ensure that the potential production of the fish stock are used to full advantage without endangering the underlying health of the stocks (conservation objective), and more recently the consideration of the wider ecosystem impacts. An objective for the fishery sector is to realise its full economic potential as measured by the sum of net economic benefits across all producers and consumers, and that economic rents are maximised. The social objective appears to be the hardest to define or identify because it can encompass a wide range of needs and preferences, including maintaining community structure and lifestyles; employment; and cultural identity and traditional practices.

Success in management is often described as the ability to produce outcomes that meet the stated objectives, but objectives and goals are complex. Trade-offs between different viewpoints need to be explicitly considered, and the interdependence of one factor on another also has to be taken into account. Success implies that management arrangements are working well, compared to previous situations, but this needs a benchmark upon which improvement can be measured, and a metrics to gauge the improvement (Bennett, 2005 pp. 21-28).

A more general point which relates to fisheries in Australia and elsewhere, is – what constitutes successful fisheries management, how would this be recognised, and what are appropriate benchmarks and standards to assess success. ESD and EBFM in moving from concept and theory to practice and implementation – what are the challenges in this shift, and how is implementation best facilitated? ESD and EBFM focus on integration – what does this mean and how is this to be achieved? Climate change is an emerging issue for Australia (as elsewhere), impacts on marine ecosystems and fish species opens up new a new research area, with appropriate management responses still under development. Chapter 9 links the conceptual aspects of ESD and EBFM as discussed in Part One of the thesis and the practice in Australia, as discussed in Part Two of the thesis.

CHAPTER 9: CONCLUSION: ECOSYSTEM BASED FISHERIES MANAGEMENT FROM CONCEPT TO PRACTICE

9.1 Introduction

Oceans and fisheries face major and complex environmental, economic and social challenges. The principle issues and major impacts to the marine environment are over-exploitation; pollution; introduced species; habitat loss and modification; and more recently impacts from climate change. The marine environment is subject to multiple uses and users, and a sectoral approach to management has failed to take into account the cumulative effects and associated impacts. These issues may also affect fishery resources and in turn the fishing industry and fishing communities. Fishing can also impact marine ecosystems directly and indirectly. Economic challenges for fisheries include the related issues of over-fishing, over-capacity and subsidies; globalisation of markets; fishing industry viability; costs and economic return on capital; and IUU. Social challenges relate to a range of dependencies such as food security; livelihood; cultural self determination; and the maintenance of fishing communities (Grafton et al., 2008; FAO, 2003; Ward et al., 2002; Charles, 2001 Sissenwine and Mace, 2001; Ecosystem Principles Advisory Panel, 1999).

Three major international initiatives addressed these challenges:

- the 1987 World Commission on Environmental Development (WECD);
- the 1992 United Nations Conference of the Environment and Development (UNECD); and
- the 2002 World Summit on Sustainable Development (WSSD).

Two key concepts that emerged from these initiatives are sustainable development and Ecosystem Based Fisheries Management (EBFM).

9.2 Using an integrated systems approach to model ESD and EBFM principles

The thesis had three aims, with the primary aim to examine the development and implementation of Ecosystems Based Fisheries Management as a framework for the management of oceans and fisheries. This involved the identification of the key concepts, aspects and elements of Ecosystem Based Fisheries Management and the identification of the key aspects of governance and management under EBFM principles.

A second aim centred on the development of an integrated systems model under EBFM principles including a comprehensive biosocioeconomic subsystems model and a comprehensive governance and management subsystems model.

A third aim was to examine how EBFM has been applied in practice to Australian fisheries. This involved the identification and assessment of the key features of EBFM development and implemention in Australia, and the identification and assessment of the main challenges to implementation.

The thesis has recognised that managing under EBFM principles is complex and one needs to understand the whole fisheries system to identify and understand the subsystems. This approach has been used throughout each stage of the thesis by way of unpacking the whole into its constituent parts and developing an understanding of the key dependencies and relationships; and repacking by discussing the importance of integrated governance and management in terms of consistency when translating from general concepts and definitions into principles, criteria, objectives, and the specific approaches for implementation. There have been very few studies that have attempted to unpack EBFM, or to study the concept to its incorporation into governance and management arrangements, and then implementation at the fishery level.

Australia was used as a case study in moving from the more theoretical and conceptual aspects, to applying the model and supporting frameworks. At the national level the model was used to identify how the principles and broad objectives outlined in the international instruments and agreements that Australia is party to, have been incorporated into the policy framework. The model has also been used as a guide to examine the application the ESD and EBFM approach adopted by Australia. The thesis examined the governance and management arrangements across different jurisdictional levels: at the national and bioregional levels; and the Commonwealth and state fisheries level. The thesis also examined how the application and implementation of EBFM is undertaken at the fishery level, through two case studies. This approach has enabled a systematic understanding of the environmental, economic and social issues facing Australia at different spatial and temporal scales. The thesis also qualitatively assessed and evaluated the key governance and management initiatives implemented at the fishery level. Applying the integrated systems model and supporting frameworks in two case studies has demonstrated that a comprehensive and consistent approach to assessing EBFM can be used, which can also provide a better understanding of the key relationships, dependencies and interactions within fishery systems.

9.3 EBFM: issues, drivers and the development of the concept

The overall objective of EBFM is to sustain healthy marine ecosystems and the fisheries they support. To achieve this objective EBFM aims to:

- avoid degradation of ecosystems as measured by indicators of environmental quality and systems;
- minimise the risk of irreversible changes to natural species assemblages and ecosystem processes;
- maintain long-term socio-economic benefits without compromising ecosystems;
- generate knowledge of ecosystem processes sufficient to understand the likely consequences of human actions; and
- where knowledge and understanding is limited the application of robust and precautionary fishery management measures should be applied (Pikitch et al., 2004).

Integration is implicit in the concept of ESD and encompasses the environmental, economic and social dimensions (often referred to as the three pillars of the concept) together with governance and management dimensions. Recently, resilience has also become an important facet of these dimensions. Translation from concept and general principles into practice, has, however, been more difficult. The concept of sustainability is context dependent, and the characterisation of the valued conditions may change as public perceptions, values, or scientific understanding change (Brinsmead, May 2005 pp. 13). Social values and beliefs play an important role in how natural resources (such as fisheries) are valued, and this in turn influences choices and decisions regarding governance and management of natural resource use. Fisheries governance and management have many goals to fulfil, stakeholders have multiple objectives, and these involve trade-offs. Moving towards EBFM requires an explicit consideration of these multiple objectives (Hanna, 1999; Rudd, 2004; Jentoft, 2004).

EBFM can complement and improve existing fisheries management approaches and other methodologies that deal with complex situations (Ecosystem Principles Advisory Panel, 1999). The EBFM approach incorporates many of the best practice aspects of existing fisheries management arrangements, and is implemented via strategies that attempt to balance diverse objectives within ecologically sustainable boundaries, given the complexity and uncertainties (Grafton et al., 2007). There is no single best way to implement the ecosystem approach, as it depends on local, national, or regional conditions. The implementation of EBFM at the national level will be influenced by the specific issues, and the different environmental, economic and social conditions of each nation. The governance and management responses to these issues may vary based on differing objectives and priorities, and stakeholder values and interests; and governance and management models (top down, bottom up or co-management). These aspects result in different approaches to the implementation of EBFM (FAO 2003; Korn et al., 2003 p. 7).

9.4 A systems approach

A systems approach was adopted as a means of unpacking EBFM and an integrated systems model developed that could be applied at a range of levels from the regional, national, state, large marine ecosystems (LMEs); and at the individual fishery levels. The development of the model enabled:

- visualisation of the fishery system under ESD and EBFM principles;
- identification of the key dimensions and relationships within and between them;
- outlining the components of underlying subsystems; and
- consideration of the integration of the whole system.

The model also aimed to provide a comprehensive and consistent approach to the implementation of EBFM, and a basis to assess the effectiveness of governance responses and management actions. The descriptive frameworks helped in developing an understanding of the system dynamics and depicting and including these in the model. These were in terms of identifying the subsystems within each of the biosocioeconomic and governance and management dimensions, and the key interdependencies and relationships within and between them, at a range of spatial and temporal scales. This revealed the complexity and the inherent uncertainties within the system. This highlighted the importance of a comprehensive and consistent approach to any proposed governance policy initiatives and management actions in response to the identified issues. The integrated fisheries system model under ESD and EBFM principles is presented below in Figure 9.4.

The integrated systems model and descriptive frameworks were used to examine Australia’s adoption of ESD and EBFM, the governance policy framework, and to review management arrangements in practice. In Chapter 6 the governance dimensions (the political agenda, the policy and planning framework and the legal framework) under ESD and EBFM principles and policy framework were presented. In Chapter 7 the model was used to assess how Australian state and Commonwealth fisheries are being managed, and how key elements underpining ESD and EBFM are being implemented. Analysis of reviews of Australia’s transition towards implementing ESD and EBFM between 1998 and 2008 provided key data, and in Chapter 8 the model was applied to two different individual fisheries (the Southern and Eastern Scalefish and Shark Fishery (SESSF) a multi-species, multi-gear, and multi-sector fishery; and the West Coast Rock Lobster Fishery (WCRLF) a single species and essentially single gear fishery).

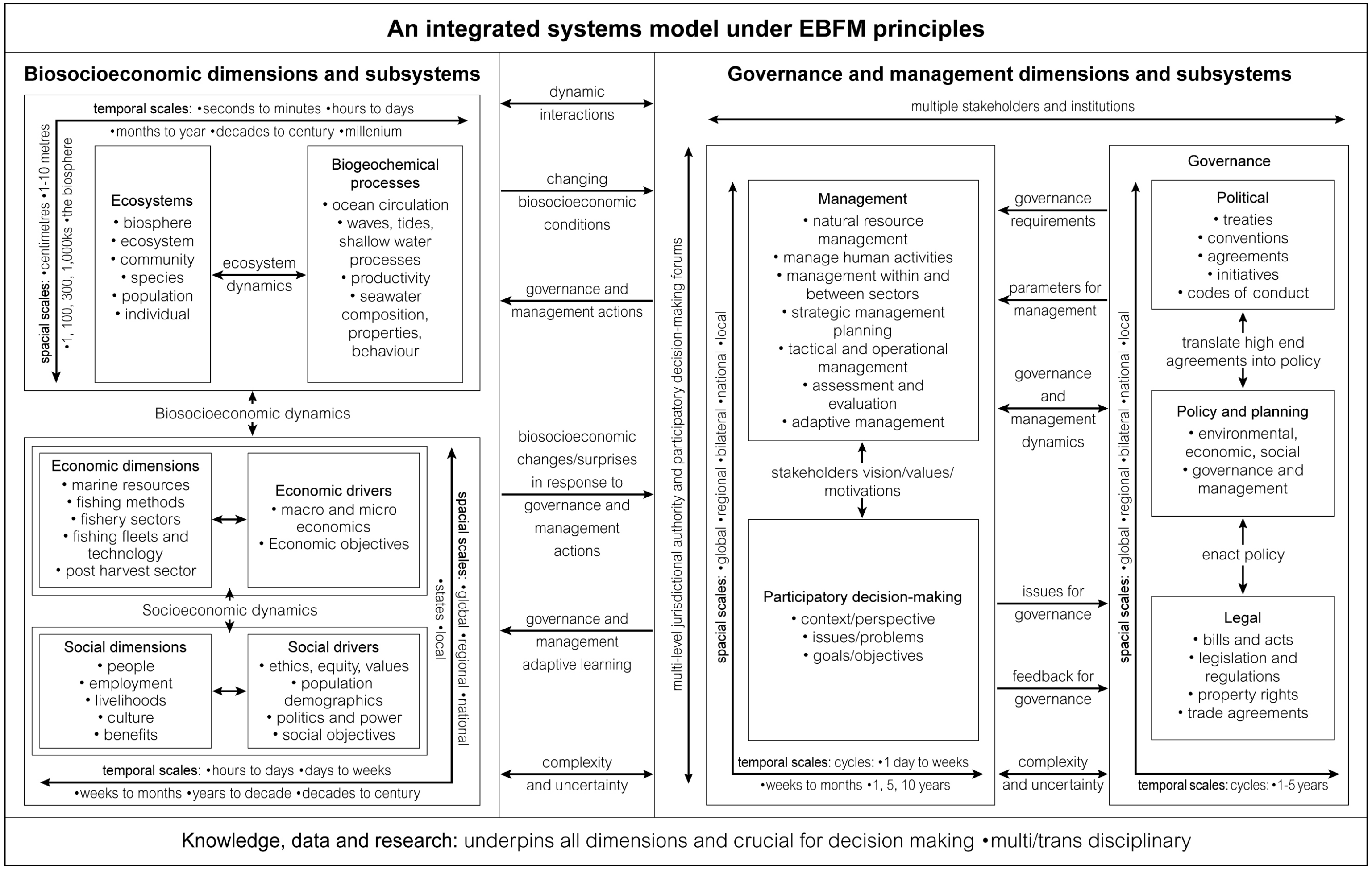


Figure 9.4: An integrated systems model under EBFM principles.

9.5 Australia: ESD and EBFM in practice

In Australia ESD and EBFM are closely linked. ESD broadly balances the environmental, economic and social. NSESD requires the integration of the environmental, economic social considerations into policy and management actions. EBFM supports these principles but under the *Environment Protection and Biodiversity Conservation* (EPBC) Act 1999, the revised bioregional plans have a narrower focus on the environmental conservation and declaration of Marine Protected Areas (MPAs); and the fisheries strategic assessments mainly focus on the environmental, with little or no consideration of economic and social dimensions. This situation results in a tension between the concepts and the application of ESD and EBFM in practice, and needs to be resolved.

Applying the systems model and descriptive frameworks to profile Australia's fisheries highlighted some of the key issues for fisheries governance and management under ESD and EBFM principles. This approach facilitated the examination of the strategic and operational management arrangements of Commonwealth fisheries managed by Australian Fisheries Management Authority (AFMA), and WA fisheries managed by the Department of Fisheries through two case study fisheries, the SESSF and the WCRLF. In Australia many of the issues for EBFM implementation and governance and management, relate to the three levels of government and the institutional jurisdictional roles and responsibilities for fisheries, which has resulted in issues of interplay and fit. This has been the case, particularly where there is still not an agreed position between the Commonwealth and state governments; and the management across fisheries jurisdictions where a common approach to the management of shared fish stocks and non-target species has not always been possible.

9.5.1 The biosocioeconomic context

In November 1994 Australia became responsible, under the United Nations Convention on the Law of the Sea, for the third largest ocean territory in the world. The Australian marine environment has unique characteristics and ecosystems and biodiversity values of national and international significance, but is largely unexplored. Australia's oceans and marine resources provide economic and social opportunities for different marine sectors, such as tourism, shipping, petroleum and gas, and fishing (Kailola et al., 1993;

Zann, 1995). The marine and estuarine environments and habitats were generally considered to be in good condition (where human settlement and land use was light), but very few could be regarded as pristine (State of the Environment Advisory Council, 1996). Many of the issues were the same as those reported in 1996, and had improved very little and in some cases worsened (Australian State of the Environment Committee, 2001). While there were no surprises or new issues since 2001, the need to resolve existing problems remained in order to stem the slow decline of environmental quality (Beeton et al., 2006). Many of the concerns related to the land marine interface and coastal development, such as loss of critical marine and coastal habitats, and declining water quality and turbidity. Some commercial wild caught fish stocks were classed as over-fished or subject to over-fishing, and for some fisheries there were issues of bycatch and impacts on marine habitats. An emerging issue for Australia, as elsewhere, is climate change.

With regard to the environmental dimension progress has been made, in moving from policy and planning, to implementation of ESD and EBFM. This can be demonstrated, for example, for target species where harvest strategies with decision rules are being introduced and these are linked to the stock assessment and total allowable catch (TACs) processes for target species, and, in some cases, also include byproduct and bycatch species. Discards are increasingly being accounted for in global TACs, thereby accounting for catches across related fisheries. Bycatch strategies for non-target species (including threatened, endangered or protected species (TEPs) and migratory species) have been considered by fisheries management in the past, but are increasingly required to be explicitly accounted for through identification in risk assessments, mitigation measures (some are mandatory), and recoding of interactions with TEPs. The role and function that habitats and ecosystems play in the marine environment and in fishery production and abundance are considered important. These are included in policy and policy initiatives, but in practice are less well understood, with management practices still being developed. Economic considerations although limited in the past, are coming to the fore due to recent macro and micro drivers and concerns relating to the viability and profitability of fisheries. This is demonstrated by annual economic surveys of selected fisheries and the recent structural adjustments aimed at responding to environmental and economic issues and challenges, for particular fisheries. The social dimension is acknowledged and considered important and referred to in policy, but in practice has not been implemented. Although methods and tools are being developed to enable the social aspects to be included into management practice, confidence in managing the social dimension is low, and uptake of methods and tools in this area has been limited, and most jurisdictions lack clear operational social objectives.

In Australia the federal policy framework (National Strategy for Ecologically Sustainable Development (NSESD), Oceans Policy and the EPBC Act) set the parameters for governance and management under ESD and EBFM principles. The policy framework and policy initiatives appear to be adequate and timely, however in light of their outcomes as reported in the *State of the Environment Reports* questions are raised regarding their effectiveness (Beeton et al., 2006). A number of policy initiatives have recently been introduced and, in theory, the outcomes and benefits from the implementation of these should flow through, and start to become apparent in the next *State of the Environment Report* due in 2011. Given that fisheries jurisdictions are at different stages of implementation of EBFM (Webb and Smith, 2008) outcomes will, however, be dependent upon how these policy initiatives are implemented.

Until recently policy was considered ahead of implementation methods and tools. Over the last ten years however, a number of methods and tools have been developed to support the implementation of ESD and EBFM. In Australia some of these were developed under the ESD subprogram, although uptake across fishery jurisdictions varies. Further development of EBFM tools has been undertaken, but others may still be required for full implementation, for example, the development, application and use of a wider suite of performance indicators. The 1998 (Sainsbury, Smith and Webb, 1998) and 2008 (Webb and Smith, 2008) reviews noted that, confidence in the use and application of indicators varied, with target species components having the highest confidence. Whereas, there was less confidence in the use of indicators related to byproduct, bycatch, TEPs species and governance components as a group; habitats, ecosystems/communities and economic components as a group; and the social component rated lowest.

There has been a shift over the last ten years however, from reliance on the use of a small subset of tools (the silver bullet approach) to dealing with a broad spectrum of issues. Tools have been developed to deal with particular issues, but are also being used and applied as a suite in dealing with the complex fisheries system issues; and in individual fisheries a wider spectrum of tools are being used for management and decision-making. Ecological Risk Assessments (ERAs) for example, are being undertaken to identify risks that fishing activities might pose to the environmental dimensions, and any uncertainties in the achievement of the stated management objectives. Given these risks and uncertainties, Management Strategy Evaluation (MSE) is being used to test different management options prior to implementation. Experience in the use of single management measures for fisheries is also highlighting the need to supplement these measures. In individual transferable quota (ITQ) fisheries, other measures such as boat Statutory Fishing Right (SFRs) can be used to ensure well managed fisheries. Mandatory measures for managing discarding or high grading; and spatial and temporal measures for managing the wider ecosystem requirements, can complement single species management measures.

9.5.2 Performance reporting, adaptive management, and information and data

There are two aspects of performance assessment. One is the ability to demonstrate the successful management of fisheries under ESD and EBFM principles. This is important internationally as Australia is party to a number of conventions and treaties, and the requirements of these have to be incorporated into domestic fisheries governance and management arrangements, and nationally it is important to a range of stakeholders with an interest in fisheries. Government and management institutions also have to be accountable to the broader Australian community who are also increasingly interested in the sustainability of fisheries and the marine environment.

Fishery management is an interactive system and the performance of the whole cannot be judged by one part. It is only by examining the whole management system and its robustness to uncertainty, that the likelihood of achieving objectives and the level of precaution required can be determined. The range of potential issues that could be reported and assessed for sustainable fisheries and marine ecosystems is wide, and requires a transparent and defendable approach. However, the reporting framework alone is not sufficient to determine whether one component, or management of the whole system, is adequate to achieve the management objectives, as performance will depend on the choice of reference points; assessment methods; management responses; and interaction between these choices across the different components (Sainsbury and Sumaila, 2003 p. 345).

In Australia performance assessment reporting is a legislative requirement for government and management institutions, and fisheries management agencies. These include the five yearly State of the Environment reports; annual fishery agency reports to Parliament; and annual fishery and economic status reports. Under the ESD subprogram, the National ESD reporting framework for fisheries (wild capture fisheries and aquaculture) was developed. The framework was designed to show how a fishery contributes to sustainable development (positively or negatively), covering all issues required for ecosystem-based management and for the economic and social assessments; and incorporates a risk assessment techniques within the framework. This approach has been applied to over 20 state managed fisheries in Western Australia, demonstrating its capability across different types of fisheries (Fletcher et al., 2005); however uptake in other fisheries jurisdictions varies. The current institutional and fisheries performance reporting processes in Australia cannot be considered as an integrated process for EBFM. Reporting quality and content varies; there is very little evaluation of available data or trend information; format of reporting styles differ so comparisons are difficult; and the timing of report production also differ. Effective capture of biosocioeconomic changes, and response to government initiatives and management actions, is important for providing feedback to develop further insights.

It is widely accepted that adequate and reliable data is required for informed decision-making. There are institutional barriers in Australia that have prevented efficient use of available data and its dissemination and communication, as well as the gaps in primary data that need addressing. Webb and Smith (2008) also highlighted particular information needs as they related to low value and data poor fisheries. There are often similar information needs between different institutions and decision makers. Therefore, it would be practical for this information to be standardised in terms of spatial and temporal scales, where necessary at the fine scale so that it may be aggregated at a range of other more coarse scales, or disaggregated according to need; collected and managed centrally; updated regularly; and made available to a wide range of users in a relevant format, to inform governance and management arrangements, and decision-making. Given the competition for research funding, a strategic approach is necessary to prioritise and better target research and ongoing data collection, data management, analysis and distribution.

9.6 Australian fisheries: where we were, where we are now, and recommendations for where we need to be

In 1998, despite the prominence of ESD as a fishery management objective in all Australian jurisdictions, it was recognised that there was a gap between intention and practice, and consistency in application. Since then a range of policy initiatives, methods and tools have been developed to support the implementation of ESD and EBFM. As demonstrated, much has been developed and achieved in the last ten years, and Australia is considered a world leader in fisheries management. However, the outcomes of the reviews and the issues discussed above highlight some aspects that required further consideration. What is now required is a period of consolidation to identify how the current issues and shortfalls are to be rectified, and how future issues are to be managed. These issues are presented in the form of recommendations relating to the current situation and future needs.

9.6.1 Current issues and recommendations

In assessing Australia's EBFM approach, the research highlighted a number of challenges for implementation.

Biosocioeconomic dimensions: the EBFM approach requires the incorporation and integration of the biological and environmental, economic and social considerations. As discussed previously, to date minimal work has been done to address economic and social factors in accordance with EBFM. To enable these factors to be incorporated into decision-making requires the setting of clearly defined policy objectives. Currently there is gap in the knowledge of how to formally encompass economic and social sustainability into the fisheries management context (Vieira et al., 2009 pp. 1-5). One difficulty in implementing EBFM is that trade-offs are inevitable, but there is very little discussion on how these trade-offs are to be made (Sanchirico et al., 2008). The focus is currently on environmental dimensions, with little consideration for the economic and social aspects, and this situation is in effect a defacto trade-off. Although there are available tools which have been developed that could be applied, others may need to be developed.

Integrated governance and management: is a process which has to interactively consider problem assessment; policy priorities; formulation and implementation of polices through adequate instruments and measures; and take into account the multiple perspectives of stakeholders. Governance systems drive policy making, and the development of management strategies, which must function efficiently for effective decision-making. The institutional framework relates to the range of institutions that together form the decision-making environment and shape the broad policies and specific instruments for governing fisheries. The overall performance of the system will depend on the level of coherence in the design of the institutional framework as a whole. Achieving a satisfactory level of coherence is a problem in fisheries because of the complexity and uncertainty inherent within ecosystems and human systems, and the interactions between them (Symes, 2007). As highlighted, in Australia there are issues of interplay and fit, which will require a comprehensive review of the whole system so as to identify where in the system these are occurring and how they might be rectified.

Implementation of EBFM in practice: EBFM requires decisions to be made for the long-term as many of the ecological processes span decades. EBFM poses new challenges to the ways problems are defined, solutions identified and actions implemented. This may confront decision makers with dilemmas that require hard choices. Choices relate to alternative courses of action, on the basis that one is considered better, in relation to a particular goal or purpose. All choices are linked to the issue of societal choice and values (Kooiman and Jentoft, 2005). Implementation of EBFM involves a wide range of possible actions and activities, and it can be difficult to identify the key actions to achieve the desired objectives and outcomes (Ward et al., 2002). Currently in Australia the confidence in managing under EBFM principles, and the application of EBFM methods and uptake of tools, varies across fisheries jurisdictions, and the reasons for these differences needs to be identified.

Integrated performance assessments: the past decade has seen a shift from traditional single species management towards integrated management approaches, which aim to address the interactions between fisheries and the wider environment, and take into account the concerns of stakeholders (including economic and social aspects) in decision-making. As the demand for more complex systems to manage fisheries has increased so has the need for assessments that can evaluate and report on the comprehensiveness and effectiveness of fishery management systems for making reliable assessments of sustainability (Leadbitter and Ward, 2007), and in regard to the implementation of EBFM. In Australia currently there is not the facility to perform an integrated assessment of the whole system under ESD and EBFM principles, although many of the building blocks are in place. An integrated performance assessment is required so that issues can be evaluated within the broader context, as well as how they relate to the detailed specifics. Without this it is going to be difficult to correctly identify where in the system the underlying problems exist, so that an appropriate adaptive governance and management response can be developed and implemented. A move towards a fully integrated systems approach and performance assessments would facilitate learning, and the identification of successful fisheries management approaches.

Data and information management: the incorporation of ESD and EBFM principles into governance and management arrangements require a broad inter-disciplinary approach that recognises a range of relevant information, both qualitative and quantitative, for effective decision-making. Improved knowledge of fishery systems and governance, and management options, are important to ensure that any governance initiatives and management actions can be monitored and adapted in response to outcomes, thus enabling learning and enhancing knowledge in a systematic manner. An inter-disciplinary approach is one in which the collaborators are working to a common plan and enabling an emerging consistency of theoretical underpinning (Bavinck et al., 2005 pp. 321-322; Symes, 2006). In Australia there are issues that have identified regarding the management, dissemination and communication of existing data as well as data gaps that require further research.

Cross sectoral issues: one of the objectives of the Oceans Policy initiative was to enable multiple use management that was capable of managing cross sectoral activities and mitigating cumulative impacts. However, under the revised bioregional plans the focus has shifted towards environmental conservation and the identification and declaration of MPAs. Despite state government attempts to legislative reform, coastal zone management remains affected by sectoral based legislation. A cross sectoral issue, that is poorly, managed, is coastal development and land-based activities which alter the marine environment. These activities may also affect fisheries production, distribution and abundance, due to the loss of critical habitat important for commercial species during their life history stages. The result of continued urban expansion, together with its attendant issues for water quality in combination with nutrients, chemicals and sediments from agricultural catchments, could become a serious issue for coastal species, habitats and ecosystems. Urban expansion also creates localised and increasing pollution haloes around these coastal areas, with the risk of some toxins entering the marine food chain. This could have economic effects for Australian fisheries exporters that rely on the current reputation of a high quality product, and domestic markets in terms of consumer confidence in food safety and in fisheries products. Therefore, the resolution of sector conflicts needs attention, as does the mitigation and management of the resulting cumulative impacts.

Marine Protected Areas and spatial management: MPAs have been considered important in providing both non-fishery and fishery benefits for the marine environment, as they can potentially act as buffers against some management miscalculations and unforeseen or unusual conditions. The conservation goals of reserves will not be met if the reserve is poorly designed, implemented or protected, and the need for social, political, and economic acceptance may compromise the biological outcomes. MPAs are embedded in larger ocean and coastal systems which, if managed in isolation are vulnerable to threats outside the MPA. Ineffective reserves and MPAs waste effort and can lead to a false sense of security about the state of the marine environment (Allison et al., 1998; Cicin-Sain and Belfiore, 2005; Ehler, 2005). Currently in Australia spatial management of the marine environment for conservation purposes is undertaken at several levels. A key provision of the EPBC Act is the declaration of MPAs as part of developing and providing a national network of comprehensive, adequate and representative MPAs under the National Representative System of Marine Protected Aareas strategy. Commonwealth and states exercise separate jurisdictional responsibility for the marine environment, with respective governments identifying and declaring MPAs, enacting legislation, developing a range of potentially different spatial management strategies and operational measures. States are also responsible for coastal zone management, which employ spatial zoning as a way of managing multiple users and uses, however, to a large extent the issues relating to a sectoral approach remain. Fisheries management have a long history of spatial management and it is an important tool under EBFM principles. These different approaches to spatial and temporal management are not integrated at the institutional level between the Commonwealth, state and local governments or between fisheries management agencies. This is not a failing of the individual approaches, but a lack of an overarching and integrated system, which will need to be rethought if spatial management approaches are to be of benefit, and effective in coastal zone management, MPA declaration, and as a fisheries management measure.

9.6.2 Future issues and scenario analysis

Scenarios and scenario analysis are tools that can provide an awareness about the future by offering alternative future images, and exploring choices of action; based on possible futures – what may happen; probable futures – what is most likely to happen; and preferable futures – what we would prefer to happen (Tonn, 2007; Duinker and Greig, 2007; Charles, 2001). Outcomes of choices and action made today will manifest in the medium to long-term, and be reflected in ecosystems and human systems, in unexpected ways, due to environmental, economic and social uncertainty, as well as the complex feedback loops within and between them. Scenario analysis and decision-making frameworks could be another useful approach to be developed for the fisheries toolbox, providing more foresight, which could also facilitate the development of proactive governance strategies rather than reactive responses.

Scenario analysis and decision-making frameworks require a broadening of thinking regarding strategic planning, and operational timelines. Governments may look to the future in terms of policy visions or statements of intent, but planning timeframes tend to be based on one year operational plans (current), and three and five year strategic plans (medium term). Consideration of environmental spatial and temporal factors and biosocioeconomic systems require governance and management responses that include a range of temporal timeframes from short to decadal to millennium, at a range of spatial scales (local, large marine ecosystems, state and national) (Garcia and Charles, 2007; Meadowcroft, 2002).

In Australia, as elsewhere, an emerging and future issue is that of climate change. Understanding the risks and predicted outcomes in terms of the biosocioeconomic effects at a range of spatial and temporal scales is a new area of research, and development for governance and management and is still at the conceptual stage. Once a broader understanding of climate change has been achieved, these factors need to be incorporated into operational fisheries management, for example harvest strategies that take into account ecosystem conditions under climate variability and change. A key challenge is the need to simultaneously govern and manage both current and emerging issues, and ongoing fishery requirements.

9.7 EBFM in Australia

Australia is considered a world leader in oceans and fisheries management. The broad principles of ESD and EBFM and the intent of the international instruments and agreements that Australia is party to have been incorporated into the national governance and management arrangements and implemented at the bioregional and fisheries level. A range of decision-making tools such as ecologicak risk assessment, qualitative and quantitative modelling, management strategy evaluation, and mapping have been used to develop, fisheries management arrangements. Fisheries management plans are an important basis for management as these set the formal or informal arrangements between fishery management institutions and the fisher stakeholders. The allocation of effective user rights is viewed as a fundamental requirement as they outline a system of rights, rules and responsibilities that guide and control the human use of the marine environment. A toolbox approach to management processes and measures has been taken, as it has been recognised that no one measure alone is likely to be effective. Fish are a renewable resource if managed and harvested on a sustainable basis, however as elsewhere this has not always been the case and many of Australia's fish stocks have been over-exploited. In response, harvest strategies have been developed and implemented in Commonwealth ans state managed fisheries and where necessary structural adjustments have been undertaken to ensure fisheries are managed on a sustainable basis as required under the EPBC Act 1999. Several Australian fisheries have been accredited by the Marine Stewardship Council as these fisheries have met the accreditation standards and demonstrated that the fish products are harvested on a sustainable basis.

The work undertaken within the ESD subprogram was according to Fletcher (2005), seen as leading the world in the implementation of ecosystem-based management (Fletcher, 2005). The 2008 review (Webb and Smith, 2008) agreed that outcomes from the work undertaken by the ESD subprogram had been a successful approach in facilitating the incorporation of ESD principles, and the development of methods and tools for the implementation of ESD for fisheries. This approach and the lessons learned provides an example of a model that could be applied to achieve the implementation of EBFM.

The key recommendations from the 2008 review were for a national forum to co-ordinate and further develop EBFM in Australia. The national forum should be represented by a wide range of stakeholders including fishery managers, industry, environmental agencies and NGOs, and various disciplinary experts. The focus of a national forum would be on the need for:

- improvements in co-ordination and consistency in approach across agency departments and between fisheries jurisdictions at the different levels;
- further development of management and assessment tools and the uptake within and across all jurisdictions;
- capability and capacity building;
- addressing data and research needs; and
- providing adequate resources for these activities (Webb and Smith, 2008).

As well as the need for a smaller, adequately resourced, and more dedicated technical team tasked with the development and implementation and co-ordination of key recommendations, which would be both responsible to, and guided by, the national forum.

9.8 From theory to practice

An important aspect of this research was to assess the model empirically by applying it to the real world as demonstrated in Part Two of the thesis, by moving from a broad conceptual approach of the adoption and practice of ESD and EBFM in Australia. The model was applied to Commonwealth and to State fisheries, providing empirical material through which to evaluate its application, by means of two case study fisheries the SESSF and the WCRLF. This research and analysis indicates that the integrated systems model and descriptive frameworks can be used to successfully represent the real world in moving from a broad conceptual approach to a detailed representation of the adoption and practice of ESD and EBFM in Australia.

The model was able to capture the key issues, changes and drivers of the environmental, economic and social dimensions at a number of spatial and temporal scales; capture the hierarchy of ecosystems and human systems; as well as some dynamic aspects of the system and subsystems, in terms of the key dependencies and relationships both within and between the biosocioeconomic and governance and management dimensions. What remains a challenge is how changes within and between them are to be tracked overtime. These biosocioeconomic dimensions provide the context for developing governance policy initiatives and identifying management actions; and the basis for assessing performance outcomes, based on clearly defined and agreed objectives, where underlying assumptions are made explicit. Together, these are important in framing the system as a whole. As a generic model it can be used to capture past, current and future fishery situations, subject to the availability of current and historical data and information, at the required spatial and temporal scales and a readily useable format.

The development and application of a systems approach and an integrated systems model has proven to be helpful in embracing the complexity and uncertainty and in simplifying it, and has provided a framework for reviewing and assessing Australia's implementation of ESD and EBFM. This is the first attempt at such an approach. The systems approach and model identified the key aspects enabling a better understanding of the complexity and interdependencies within Australia's oceans and fisheries systems. This approach allows movement from an integrated whole to linked parts, each sphere informing the other. This was both the starting and concluding point of this thesis, which is eloquently described by Ken Wilber (1997).

To understand the whole, it is necessary to understand the parts. To understand the parts, it is necessary to understand the whole. Such is the circle of understanding. We move from part to whole and back again, and in that dance of comprehension, in that amazing circle of understanding, we come alive to meaning, to value and to vision: the very circle of understanding guides our way, weaving together the pieces, healing the fractures, mending the torn and tortured fragments, lighting the way ahead- this extraordinary movement from part to whole and back again, with healing the hallmark of each and every step, and grace the tender reward (Wilber, 1997 p. 1).

REFERENCES

Chapter 1

Caddy, J. (1999) Fisheries management in the twenty-first century: will new paradigms apply? *Fish Biology and Fisheries* 9:1-43.

Caddy, J. and Cochrane, K. (2001) A review of fisheries management past and present and some future perspectives for the third millennium. *Ocean and Coastal Management* 44:653-682.

Charles, A. (2001) *Sustainable fishery systems.* Blackwell Science, Oxford.

Ecosystem Principles Advisory Panel (EPAP) (1999) *Ecosystem-based fishery management.* A report to Congress by EPAP. National Marine Fisheries Services, Silver Spring, Maryland.

Food and Agricultural Organisation (FAO) of the United Nations (2003) *Fisheries management. 2. The ecosystem approach to fisheries.* FAO Technical Guidelines for responsible fisheries No.4, Supplement 2. FAO, Rome.

Food and Agriculture Organization (FAO) of the United Nations (2009) *The state of world fisheries and aquaculture 2008.* FAO, Rome.

Garcia, S. and Cochrane, K. (2005) Ecosystem approach to fisheries: a review of implementation guidelines. *ICES Journal of Marine Science* 62:311-318.

Garcia, S. and Charles, A. (2007) Fishery systems and linkages: from clockworks to soft watches. *ICES Journal of Marine Science* 64: 580-587.

Garcia, S., and de Leiva Moreno, I. (2003) Global overview of marine fisheries in *Responsible fisheries in the marine ecosystem.* Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

George, A. (1979) Case studies and theory development: the method of structured, focused comparison in *Diplomacy.* Ed. Lauren, P. The Free Press, New York.

Hartje, V., Klaphake, A., and Schliep, R. (2003) *The international Debate on the ecosystem approach: critical review, international actors, obstacles and challenges.* BfN-Skrpten 80. Bundesmat fur Naturschutz (BfN), Federal Agency for Nature Conservation, Germany.

Johnson, S. (1995) *The Earth summit: the United Nations conference on Environment and Development (UNCED).* International Environmental Law and Policy Series. Graham and Trotman/Martinus Nijhoff, London.

Kaiser, M., Attril, M., Jennings, S., Thomas, D., Barnes, D., Brierley, A., Polunin, N., Raffaelli, D., and Williams P. (2005) *Marine ecology: processes, systems and impacts.* Oxford University Press, Oxford.

King, M., (2007) *Fisheries biology, assessment and management.* Fishing News Books a Division of Blackwell Science Ltd., Oxford.

Korn, H., Schliep, R., and Stadler, J. Eds. (2003) *Report of the international workshop on the further development of the ecosystem approach.* BfN-Skrpten 78. Bundesmat fur Naturschutz (BfN), Federal Agency for Nature Conservation, Germany.

Murawski, S. (2000) Definitions of overfishing from an ecosystem perspective. *ICES Journal of Science* 57:649-658.

Pikitch, E., Santora, C., Babcock, E., Bakun, A., Bonfil, R., Conover, D., Dayton, P., Doukakis, P., Fluharty, D., Heneman, B., Houde, E., Link, J., Livingston, P., Mangel, M., McAllister, M., Pope, J., and Sainsbury, K. (2004) Ecosystem-based fishery management. *Science* 305: 346-347.

Reid, D. (1995). *Sustainable development: an introductory guide*. Earthscan Publications, London.

Roberts, G. (1978) The explanation of politics: comparison, strategy and theory in *The practice of comparative politics.* Eds. Lewis, P., Potter, D., and Castles, F. Longman, London.

Sainsbury, K, Smith, A. Webb, H. (1998) C*urrent use and recommendations for future development of sustainability indicators to measure performance of Australian fisheries against ESD objectives.* FRDC project No. 98/168. Fisheries Research and

Development Corporation and Commonwealth Scientific and Industrial Research Organisation, Hobart, Tasmania.

Sissenwine, M. and Mace, P. (2003) Governance for responsible fisheries: an ecosystem approach in *Responsible fisheries in the marine ecosystem.* Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

Ward, T., Tarte, D., Hegerl, E., Short, K. (June 2002) *Policy proposals and operational guidance for ecosystem-based management of marine capture fisheries.* World Wide Fund for Nature (WWF), Australia.

Webb, H., and Smith, T. (2008) *Review of the scope, assessment methods and management responses for fisheries ESD and EBFM in Australia.* FRDC Report 2004/101. Fisheries Research and Development Corporation and Commonwealth Scientific and Industrial Research Organisation, Hobart, Tasmania.

United Nations (2002) *Report of the World Summit on Sustainable Development Johannesburg, South Africa 26 August -4 September 2002.* United Nations, New York.

World Commission on Environment and Development (1987) *Our common future.* Oxford University Press, Oxford.

Chapter 2

Alder, J., and Pauly, D. (2008) Aggregate performance of countries in managing their EEZs in *A comparative assessment of biodiversity, fisheries and aquaculture in 53 countries' Exclusive Economic Zones.* Fisheries Centre Research Reports Volume 16 Number 7. Fisheries Centre, University of British, Columbia, Canada.

Allio, L., Ballantine, B., and Meads, R. (2006) Enhancing the role of science in the decision-making of the European Union. *Regulatory Toxicology and Pharmacology* 44:4-13.

Alverson, D. (2002) Factors influencing the scope and quality of science and management decisions: the good, the bad and the ugly. *Fish and Fisheries* 3:3-19.

Anderies, J., Walker, B., and Kinzig, A. (2006) Fifteen weddings and a funeral: case studies and resilience based management in *Exploring resilience in social-ecological systems: comparative studies and theory development.* Eds. Walker, B., Anderies, J., Kinzig, A., and Ryan, P. Commonwealth Scientific and Industrial Research Organisation, Australia.

Aqorau, T. (2003). Obligations to protect marine ecosystems under international conventions and other legal instruments in *Responsible fisheries in the marine ecosystem.* Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

Beamish, R., McFarlane, G., and Benson, A. (2006) Longevity overfishing. *Progress in Oceanography* 68:289-302.

Berkes, F., and Folke, C. (2000) Linking social and ecological systems for resilience and sustainability in *Linking social and ecological systems: management practices and social mechanisms for building resilience.* Eds. Berkes, F., Folke, C., and Colding, J. Cambridge University Press, Cambridge, UK.

Berkes, F., and Folke, C. (2002) Back to the future: ecosystem dynamics and local knowledge in *Panarchy.* Island Press, Washington, USA.

Bernal, P., Cincin-Sain, B., Belfiore, S., and Barbiere, J. (2001) Co-Chairs summary in *Toward the 2002 World Summit on Sustainable Development Johannesburg: ensuring the sustainable development of oceans and coasts a call to action.* Intergovernmental

Oceanographic Commission, UNESCO, Paris and Centre for the Study of Marine Policy University of Delaware, USA.

Botsford, L., Castilla, J., and Peterson, C. (1997) The management of fisheries and marine ecosystems. *Science* 277:5325, pp. 509-515.

Brodziak, J., Cadrin, S., Legault, C., and Murawski, S. (2008) Goals and strategies for rebuilding New England groundfish stocks. *Fisheries Research* 94:355-366.

Brussard, P., Reed, J., and Tracy, C. (1998) Ecosystem management: what is it really? *Landscape and Urban Planning* 40:9-20.

Caddy, J. (2007) *Using questionnaires on the Code of Conduct for Responsible Fisheries as diagnostic tools in support of fisheries management.* Eds. Reynolds, J., and Greig, G. FAO Fish Code Review No. 21. FAO, Rome.

Carson, R. (1962) *Silent spring.* Houghton Mifflin, New York.

Charles, A. (2001) *Sustainable fishery systems.* Blackwell Science, Oxford.

Christensen, N., Bartuska, A., Brown, J., Carpenter, S., D'Antonio, C., Francis, R., Franklin, J., MacMahon, J., Noss, R., Parsons, D., Peterson, C., Turner, M., and Woodmansee, R. (1996). The Report of the Ecological society of America Committee on the scientific basis for ecosystem management. *Ecological Applications* 6 (3):665-691.

Cochrane, K. and Doulaman, D. (2005) The rising tide of fisheries instruments and the struggle to keep afloat. *Philosophical Transactions of the Royal Society London B Biological Sciences* 360 (1453): 77-94.

Costanza, R., Farber, S., Costaneda, B., and Grasso, M. (2001) Green national accounting: goals and methods in *The economics of nature and the nature of economics.* Eds. Cleveland, C., Stern, D., and Costanza, R. in association with the International Society for Ecological Economics. Edward Elgar Publishing Ltd., Cheltenham, UK.

Dyoulgerov, M.(2000) Global legal instrument on the marine environment at the year 2000 in *Seas at the Millennium: an environmental evaluation*. Ed. Sheppard, C. Elsevier Science, New York.

Ecosystem Principles Advisory Panel (EPAP) (1999) *Ecosystem-based fishery management*. A report to Congress by EPAP. National Marine Fisheries Services, Silver Spring, Maryland.

Edeson, W. (2005) A brief introduction to the principal provisions of the international legal regime governing fisheries in the EEZ in *A sea change: the Exclusive Economic Zone and governance institutions for living marine resources.* Eds. Ebbin, S., Hoel, A., and Sydnes, A. Springer, Dordrecht, The Netherlands.

Essington, T., Beaudreau, A., and Wiedenmann, J. (2006) Fishing through marine food webs. *PNAS* 103(9):3171-3175.

Folke, C., Berkes, F., and Colding, J. (2000) Ecological practices and social mechanisms for building resilience and sustainability in *Linking social and ecological systems: management practices and social mechanisms of building resilience.* Eds. Berkes, F. and Folke, C. Cambridge University Press, Cambridge, UK.

Food and Agricultural Organisation (FAO) of the United Nations (1995) *Code of conduct for responsible fisheries.* FAO, Rome.

Food and Agricultural Organisation (FAO) of the United Nations (1999a) *International Plan of Action for reducing incidental catch of seabirds in longline fisheries.* FAO, Rome.

Food and Agricultural Organisation (FAO) of the United Nations (1999b) *International Plan of Action for the conservation and management of sharks.* FAO, Rome.

Food and Agricultural Organisation (FAO) of the United Nations (1999c) *International Plan of Action for the management of fishing capacity.* FAO, Rome.

Food and Agricultural Organisation (FAO) of the United Nations (2001) *International Plan of Action to prevent, deter and eliminate Illegal, Unreported and Unregulated fishing.* FAO, Rome.

Food and Agricultural Organisation (FAO) of the United Nations (2002) *Implementation of the international plan of action to prevent, deter and eliminate illegal, unreported and unregulated fishing.* FAO Technical Guidelines for Responsible Fisheries No.9. FAO, Rome.

Food and Agricultural Organisation (FAO) of the United Nations (2003) *Fisheries management. 2. The ecosystem approach to fisheries.* FAO Technical Guidelines for Responsible Fisheries No.4, Supplement 2. FAO, Rome.

Food and Agriculture Organization (FAO) of the United Nations (2004) *The state of world fisheries and aquaculture 2004.* FAO Rome.

Food and Agriculture Organization (FAO) of the United Nations (2007) *The state of world fisheries and aquaculture 2006.* FAO Rome.

Food and Agricultural Organisation (FAO) of the United Nations (2008) *Fisheries management. 3. managing fishing capacity.* FAO Technical Guidelines for Responsible Fisheries No. 4, Supplement 3. FAO, Rome.

Food and Agriculture Organization (FAO) of the United Nations (2009) *The state of world fisheries and aquaculture 2008.* FAO Rome.

Gallopin, G. (2002) Planning for resilience: scenarios, surprises, and branch points in *Panarch.y* Island Press, Washington, USA.

Garcia, S. (2005) Fishery science and decision making: dire straights to sustainability. *Bulletin of Marine Science* 76(2):171-196.

Garcia, S. and Newton, C. (1997) Current situations, trends and prospects in world capture fisheries in *Global trends in fisheries management.* Eds. Pikitch, E., Huppert, D., and Sissenwine M. American Fisheries Society Symposium 20. American Fisheries Society, Bethesda, Maryland.

Garcia, S., Zerbi, A. Aliamume C., De Chi, T., and Lasserre, G. (2003) *The ecosystem approach to fisheries: issues, terminology, principles, institutional foundations, implementation and outlook.* FAO Fisheries Technical Paper 443. FAO, Rome.

Garcia, S. and Charles, A. (2007) Fishery systems and linkages: from clockworks to soft watches. *ICES Journal of Marine Science* 64: 580-587.

Garcia, S. and Charles, A. (2008) Fishery systems and linkages: implications for science and governance. *Ocean and Coastal Management* 51:505-527.

Gooday, P. (2002) *Fisheries subsidies.* Australian Bureau of Agriculture and Resource Economics Report to the Fisheries Resources Research Fund. Australian Bureau of Agriculture and Resource Economics, Canberra, ACT.

Greboval, D., and Munro, G. (1999) Overcapitalisation and excess capacity in world fisheries: underlying economics and methods of control in *Managing fishing capacity: selected papers on underlying concepts and issues.* Ed. Greboval, D. FAO Fisheries Technical Paper No. 386 FAO, Rome.

Grumbine, R. E. (March 1994) What is ecosystem management. *Conservation Biology* 8 (1): 27-38.

Hall, S. (1999) *The effects of fishing on marine communities.* Blackwell Science, Oxford.

Harding, R. (1998) *Environmental decision-making: the roles of scientists, engineers and the public.* The Federation Press, Sydney.

Hartje, V., Klaphake, A., and Schliep, R. (2003) *The international debate on the ecosystem approach: critical review, international actors, obstacles and challenges.* BfN-Skrpten 80. Bundesmat fur Naturschutz (BfN), Federal Agency for Nature Conservation, Germany.

Hilborn, R.(2007a) Moving to sustainability by learning from successful fisheries. *Ambio* 36(4):296-303.

Hilborn, R.(2007b) Reinterpreting the state of fisheries and their management. *Ecosystems* 10:1362-1369.

Hilborn R. (2007c) Defining success in fisheries and conflicts in objectives. *Marine Policy* 31:153-158.

Holling, C., Gunderson, L. and Ludwig, D. (2002) In quest of a theory of adaptive change in *Panarchy.* Island Press, Washington, USA.

Johnson, S. (1993) *The Earth summit: the United Nations Conference on Environment and Development (UNCED).* International Environmental Law and Policy Series. Graham and Trotman/Martinus Nijhoff, London.

Kaiser, M., Attril, M., Jennings, S., Thomas, D., Barnes, D., Brierley, A., Polunin, N., Raffaelli, D., and Williams P. (2005) *Marine ecology: processes, systems and impacts.* Oxford Univeristy Press, Oxford.

Keating, M. (2000) The pressure for change in *The future of governance.* Eds. Davis, G., and Keating, M. Allen and Unwin, St Leonards, NSW, Australia.

Kimball, L.A. (2001*) Intergovernmental Ocean Governance: using international law and organizations to manage marine resources sustainably.* IUCN, Gland, Switzerland.

King, M., (2007) *Fisheries biology, assessment and management.* Fishing News Books a Division of Blackwell Science Ltd., Oxford.

Kirkwood, G., and Agnew, D. (2004) Deterring IUU fishing in *Management of shared fish stocks.* Eds. Payne, A., O'Brien, C. and Rogers, S. Blackwell Publishing Ltd., Oxford, UK.

Korn, H., Schliep, R., and Stadler, J. (Eds.) (2003) *Report of the international workshop on the further development of the ecosystem approach.* BfN-Skrpten 78. Bundesmat fur Naturschutz (BfN), Federal Agency for Nature Conservation, Germany.

Lackey, R., (1998) Seven pillars of ecosystem management. *Landscape and Urban Planning* 40:21-30.

Le Gallic, B. (2004) Using trade measures in the fight against IUU fishing: opportunities and challenges in *Proceedings of the twelfth biennial IFET conference.* Tokyo, Japan, 26-30 July, 2004.

Le Gallic, B. (2008) The use of trade measures against illicit fishing: economic and legal considerations. *Ecological Economics* 64:858-866.

Le Gallic, B., and Cox, A. (2006) An economic analysis of illegal, unreported and unregulated (IUU) fishing: key drivers and possible solutions. *Marine Policy* 30:689-695.

Link, J. (2005) Translating ecosystem indicators into decision criteria. *ICES Journal of Marine Science* 62:569-576.

Mace, P. (1997) Developing and sustaining world fisheries resources: the state of science and management in *Developing and sustaining world fisheries resources: the state of science and management.* Eds. Hancock, D., Smith, D. Grant, A., and Beumer, J. 2nd edition. World Fisheries Congress proceedings. Commonwealth Scientific and Industrial Research Organisation, Collingwood, Australia.

Mace, P. (2004) In defence of fisheries scientists, single species models and other scapegoats: confronting the real problems. *Marine Ecology Progress Series* 274:285-291.

Mahon, R., McConney, P., and Roy, R. (2008) Governing fisheries as complex adaptive systems. *Marine Policy* 32:104-112.

Mangel, M., Talbot, L., Meffe, G., Agardy, T., Alverson, D., Barlow, J., Botkin, D., Budowski, G., Clark, T., Cooke, J., Crozier, R., Dayton, P., Elder, D., Fowler, C., Funtowicz, S., Giske, J., Hofman, R., Holt, S., Kellert, S., Kimball, L., Ludgwig, D., Magnusson, K., Malayang III, B., Mann, C., Norse, E., Northridge, S., Perrin, W., Perrings, C., Peterman, R., Rabb, G., Regier, H., Reynolds III, J., Sherman, K., Sissenwine, M., Smith, T., Starfield, A., Taylor, R., Tillman, M., Toft, C., Twiss Jr, J., Wilen, J., and Young, T. (1996) Principles for the conservation of wild living resources. *Ecological Applications* 6 (2):338-362.

McPhee, D. (2008) *Fisheries management in Australia.* The Federation Press, Sydney, Australia.

Meadows, D., Meadows, D., Randers, J., and Behrens, W. (1972) *The limits to growth.* Pan Books, London.

Metzner, R., and Rawlinson, P. (1998) *Fisheries structural adjustment: towards a national framework.* Prepared for the Management Committee Standing Committee for

Fisheries and Aquaculture, Australia. Fisheries and Aquaculture Branch, Department of Primary Industries and Energy, Canberra, ACT.

Milazzo, M. (1998) *Subsidies in world fisheries: a re-examination.* World Bank Technical Paper No. 406. The World Bank, Washington DC.

Morishita, J. (2008) What is the ecosystem approach for fisheries management. *Marine Policy* 32:19-26.

Murawski, S. (2000) Definitions of overfishing from an ecosystem perspective. *ICES Journal of Science* 57:649-658.

Parma, A., Hilborn, R., and Orensanz, J. (2006) The good, the bad and, the ugly: learning from experience to achieve sustainable fisheries. *Bulletin of Marine Science* 78(3):411-428.

Pascoe, S., Kirkley, J., Greboval, D. and Morrison-Paul, C. (2003) *Measuring and assessing capacity in fisheries. 2. Issues and methods.* FAO Fisheries Technical Paper No.433/2. FAO, Rome.

Pauly, D., Christensen, V., Dalsgaard, J., Froese, R., and Torres Jr, F.(1998) Fishing down marine food webs. *Science* 279:860-863.

Pauly, D., Vily, C., Guenette, S., Pitcher, T., Sumaila, R.,Walters C., Watson R., and Zeller, D. (2002) Towards sustainability in world fisheries. *Nature* 418:689-695.

Pikitch, E., Santora, C., Babcock, E., Bakun, A., Bonfil, R., Conover, D., Dayton, P., Doukakis, P., Fluharty, D., Heneman, B., Houde, E., Link, J., Livingston, P., Mangel, M., McAllister, M., Pope, J., and Sainsbury, K. (2004) Ecosystem-based fishery management. *Science* 305: 346-347.

Pitcher, T. (2005) Back-to-the-future: a fresh policy initiative for fisheries and a restoration ecology for ocean ecosystems. *Philosophical Transactions of the Royal Society London B Biological Sciences* 360 (1453):107–121.

Pitcher, T., Kalikoski, D., and Pramod, G. Eds. (2006) *Evaluation of compliance with the FAO (UN) Code of Conduct for Responsible Fishing.* Fisheries Centre Research

Reports Volume 14 No. 2. The fisheries Centre, University of British Columbia, Vancouver, B.C., Canada.

Pitcher, T., Kalikoski, D., Short, K., Varkey, D., and Pramod, G. (2009) An evaluation of progress in implementing ecosystem-based management of fisheries in 33 countries. *Marine Policy* 33:223-232.

Pritchard, L., and Sanderson, S. (2002) The dynamics of political discourse in seeking sustainability in *Panarchy.* Island Press, Washington, USA.

Reid, D. (1995) *Sustainable development: an introductory guide.* Earthscan Publications, London.

Rice, J. (2008) Can we manage ecosystem in a sustainable way? *Journal of Sea Research* 60:8-20.

Schorr, D. (2004) Healthy fisheries, sustainable trade: crafting new rules on fishing subsidies in the World Trade Organisation. A WWF position paper and technical resource. World Wide Fund for Nature (WWF).

Schrank, W. (2003) *Introducing fisheries subsidies.* FAO Fisheries Technical Paper No. 437. FAO, Rome.

Sissenwine, M. and Mace, P. (2003) Governance for responsible fisheries: an ecosystem approach. in *Responsible fisheries in the marine ecosystem.* Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

Sumaila, U., Alder, J., and Keith, J. (2006) Global scope and economics of illegal fishing. *Marine Policy* 30:696-703.

Sumaila, U., Khan, A., Watson, R., Munro, G., Zeller, D., Baron, N., and Pauly, D. (2007) The World Trade Organisation and global fisheries sustainability. *Fisheries Research* 88:1-4.

Sutinen, J. and Soboil, M. (2003) The performance of fisheries management systems and ecosystem challenge in *Responsible fisheries in the marine ecosystem.* Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

Tonn, B. (2003) The future of futures decision making. *Futures* 35:673-688.

Tsamenyi, M., and McIlgorm, A. (1999) *International environmental instruments: their effect on the fishing industry.* Second Edition. The report of the FRDC (Fisheries Research and Development Corporation) Project 97/149. Dominion Consulting Pty. Ltd., NSW, Australia.

United Nations (1982) *United Nations Law of the Sea Convention* (UNLOSC) *1982*.

United Nations (1992) *Convention on Biological Diversity* (5 June 1992).

United Nations (2002) *Report of the World Summit on Sustainable Development Johannesburg, South Africa 26 August-4 September 2002.* United Nations, New York.

United Nations Conference on the Environment and Development (UNCED (1992a) *Rio Declaration.* United Nations Department of Public Information, New York, USA.

United Nations Conference on the Environment and Development (UNCED) (1992b) *Agenda 21.* United Nations Department of Public Information, New York, USA.

United Nations Department of Economic and Social Affairs Division for Sustainable Development (2009*) Commission on Sustainable Development (CSD) multi- year programme of work for CSD 2004/05 to 2016/2017,* viewed 2 February 2010 <http://www.un.org/esa/dsd/csd/csd_mulityearprogwork.html>

Walker, B., Anderies, J., Kinzig, A., and Ryan, P. (2006) Introduction in *Exploring resilience in social-ecological systems: comparative studies and theory development.* Eds. Walker, B., Anderies, J., Kinzig, A., and Ryan, P. Commonwealth Scientific and Industrial Research Organisation, Australia.

Ward T., Alder J., Margules C., Sainsbury K., Tarte D., and Zann L. (1997) *Biodiversity conservation: the major issues relating to the effective conservation of biological diversity in Australia's marine realm.* Issues Paper No. 7. A Report commissioned by Environment Australia. Department of the Environment Canberra, Australia.

Ward, T., Tarte, D., Hegerl, E., Short, K. (June 2002) *Policy proposals and operational guidance for Ecosystem-Based Management of marine capture fisheries.* World Wide Fund for Nature (WWF), Australia.

Ward, J., Kirkley, J., Metzner, R., and Pascoe, S. (2004) M*easuring and assessing capacity in fisheries. 1. Basic concepts and management options*. FAO Fisheries Technical Paper No. 443/1. FAO, Rome.

Watling, L, and Norse, E. (1998) Disturbance of the seabed by mobile fishing gear: a comparison to forest clear cutting. *Conservation Biology* 12:1180-1197.

Westley, F. (2002) The devil in the dynamics: adaptive management on the front lines in *Panarchy.* Island Press, Washington, USA.

Westley, F., Carpenter, F., Brock, W., Holling, C. and Gunderson, L. (2002) Why systems of people and nature are not just social and ecological systems in *Panarchy.* Island Press, Washington, USA.

White, L. Jr. (1967) The historical roots of our ecological crisis. *Science* 155:1203-1207.

World Commission on Environment and Development (WECD) (1987) *Our common future.* Oxford University Press, Oxford, UK.

Worm, B., Barbier, E., Beaumont, N., Duffy, J., Folke, C., Halpern, B., Jackson, J., Lotze, H., Micheli, F., Palumbi, S., Sala, E., Selkoe, K., Stachowicz, J., and Watson, R. (2006) Impacts of biodiversity loss on ocean ecosystem services. *Science* 314:787-790.

Worm, B., Hilborn, R., Baum, J., Branch, T., Collie, J., Costello, C., Fogarty, M., Fulton, E., Hutchings, J., Jennings, S., Jensen, O., Lotze, H., Mace, P., McClanahan, T., Minto, C., Palumbi, S., Parma, A., Ricard, D., Rosenberg, A., Watson, R., and Zeller, D. (July 2009) Rebuilding global fisheries. *Science* 325:578-585.

Chapter 3

Ababouch, L. (2006) Assuring fish safety and quality in international trade. *Marine Pollution Bulletin* 53:561-568.

Anderies, J., Walker, B., and Kinzig A. (2006) Fifteen weddings and a funeral: case studies and resilience-based management in *Exploring resilience in social-ecological systems: comparative studies and theory development.* Eds. Walker, B., Anderies, J., Kinzig, A., and Ryan. P. Commonwealth Scientific and Industrial Research Organisation, Australia.

Barbier, E., Burgess, J., and Folke, C. (1995) *Paradise lost? The ecological economics of biodiversity.* Earthscan Publications Ltd., London.

Berkes, F., Colding, J., and Folke, C. (2003) Introduction in *Navigating social-ecological systems: building resilience for complexity and change.* Cambridge University Press, Cambridge, UK.

Boesch, D. (2000) Measuring the health of the Chesapeake Bay: toward integration and prediction. *Environmental Research Section* 82:134-142.

Brunk, C., and Dunham, S. (2000) Ecosystem justice in the Canadian fisheries in *Just fish: ethics and Canadian marine fisheries.* Eds. Coward, H., Ommer, R., and Pitcher, T. Social and Economic Papers No. 23. Institute of Social and Economic Research, Memorial University of Newfoundland, Canada.

Brussard, P., Reed, J., and Tracy, C. (1998) Ecosystem management: what is it really? *Landscape and Urban Planning* 40:9-20.

Caddy, J., and Seijo, J. (2005) This is more difficult than we thought! The responsibility of scientists, managers and stakeholders to mitigate the unsustainability of marine fisheries. *Philosophical Transactions of the Royal Society of London Series B Biological Sciences* 360 (1453): 59-75.

Charles, A. (2001) *Sustainable fishery systems.* Blackwell Science, Oxford.

Christensen, N., Bartuska, A., Brown, J., Carpenter, S., D'Antonio, C., Francis, R., Franklin, J., MacMahon, J., Noss, R., Parsons, D., Peterson, C., Turner, M., and

Woodmansee, R. (1996) The Report of the Ecological Society of America Committee on the scientific basis for ecosystem management. *Ecological Applications* 6 (3):665-691.

Chuenpagdee, R., Degnbol, P., Bavinck, M., Jentoft, S., Johnson, D., Pullin, R., and Williams, S. (2005) Challenges and concerns in capture fisheries and aquaculture in *Fish for life: interactive governance for fisheries.* Eds. Kooiman, J., Bavinck, M., Jentoft, S., and Pullin, R. MARE Publication Series No.3. Amsterdam University Press, Amsterdam.

Clark, C. W. (1989) Bioeconomics in *Perspectives in ecological theory*. Eds. Roughgarden, J., May, R., and Levin, S. Princeton. University Press, New Jersey.

Committee on Biological Diversity in Marine Systems (1995) *Understanding marine biodiversity: a research agenda for the nation.* National Academy Press Washington, DC.

Connell, S. and Gillanders, B. (2007) *Marine ecology.* Oxford University Press, Melbourne, Australia.

Cook, R. (2003) The magnitude and impact of by-catch mortality by fishing gear in *Responsible fisheries in the marine ecosystem.* Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

Cooke, S., and Cowx, I. (2006) Contrasting recreational and commercial fishing: searching for common issues to promote unified conservation of fisheries resources and aquatic environments. *Biological Conservation* 128:93-108.

Costanza, R. (2000) The ecological, economic, and social importance of the oceans in *Seas at the millennium: an environmental evaluation*. Ed. Sheppard, C. Elsevier Science, New York.

Costanza, R., and Mageau, M. (1999) What is a healthy ecosystem? *Aquatic Ecology* 33:105-115.

Costanza, R., and Patten, B. (1995) Defining and predicting sustainability. *Ecological Economics* 15:193-196.

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R., Paruelo, J., Raskin, R., Sutton, P., and can den Belt, M. (1997) The value of the world's ecosystem services and natural capital. *Nature* 387:253-260.

Costanza, R., Farber, S., Castaneda, B., and Grasso, M. (2001) Green national accounting: goals and methods in *The economics of nature and the nature of economics.* Eds. Cleveland, C., Stern, D., Costanza, R. in association with the International Society for Ecological Economics and Edward Elgar Publishing Ltd, Cheltenham, UK.

Crowder, L., Hazen, E., Avissar, N., Bjorkland, R., Latanich, C., and Ogburn, M. (2008) The impacts of fisheries on marine ecosystems and the transition to ecosystem-based management. *Annual Review of Ecology and Systematics* 39:259-278.

Curry, P., Shannon, L., and Shin, Y. (2003) The functioning of marine ecosystems: a fisheries perspective in *Responsible fisheries in the marine ecosystem.* Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

Daily, G. (1997) What are ecosystem services in *Nature's services: societal dependence on natural ecosystems.* Ed. Daily, G. Island Press, Washington, D.C.

Davis, A., and Jentoft, S. (2001) The challenges and the promise of indigenous peoples' fishing rights: from dependency to agency. *Marine Policy* 25:223-237.

Davis, G., Wanna, J., Warhurst, J. and Weller, P. (1993) *Public policy in Australia.* 2nd edition, Allen and Unwin, Sydney.

Degnobol, P., Gislason, H., Hanna, S., Jentoft, S., Nielsen, J., Sverdrup-Jensen, S., and Wilson, D. (2006) Painting the floor with a hammer: technical fixes in fisheries management. *Marine Policy* 30:534-543.

De Young, C., Charles, A., and Hjort, A. (2008) *Human dimensions of the ecosystem approach to fisheries: an overview, of context, concepts, tools and methods.* FAO Fisheries Technical Paper 489. FAO, Rome.

Ecosystem Principles Advisory Panel (EPAP) (1999) *Ecosystem-based Fishery Management.*. A report to Congress by the EPAP. National Marine Fisheries Services, Silver spring, Maryland.

Feely, R., Sabine, C., Lee, K., Berelson, W., Kleypas, J., Fabry, V., Millero, F., (2004) Impact of Anthropogenic CO2 on the $CaCO_3$ System in the Oceans. *Science* 305: 362-366.

Folke, C., Colding, J., and Berkes, F. (2003) Synthesis: building resilience and adaptive capacity in social-ecological systems in *Navigating social-ecological systems: building resilience for complexity and change.* Cambridge University Press, Cambridge, UK.

Food and Agricultural Organisation (FAO) of the United Nations (2003) *Fisheries management. 2. The ecosystem approach to fisheries.* FAO Technical Guidelines for responsible fisheries No.4, Supplement 2. FAO, Rome.

Food and Agricultural Organisation (FAO) of the United Nations (2004) *The state of world fisheries and aquaculture.* FAO, Rome.

Food and Agricultural Organisation (FAO) of the United Nations (2005) *Ethical issues in fisheries.* FAO Ethics Series No.4. FAO, Rome.

Food and Agriculture Organization (FAO) of the United Nations (2006) *State of world aquaculture.* FAO Fisheries Technical Paper 500. FAO, Rome.

Food and Agriculture Organization (FAO) of the United Nations (2007) *The state of world fisheries and aquaculture 2006.* FAO, Rome.

Food and Agriculture Organization (FAO) of the United Nations (2009) *The state of world fisheries and aquaculture 2008.* FAO, Rome.

Food and Agricultural Organisation (FAO) of the United Nations (2010) *FAO Fisheries Glossary*, viewed 1 February 2010 <http://www.fao.org/fi/glossary/main.asp>

Frankic, A., and Hershner, C. (2003) Sustainable aquaculture: developing the promise of aquaculture *Aquaculture International* 11:517-530.

Fulton, E. Smith, A. Webb, H. and Slater, J. (2004) *Ecological indicators for the impacts of fishing on non-target species, communities and ecosystems: review of* *potential indicators.* AFMA Report Number R99/1546. Australian Fisheries Management Authority and Commonwealth Scientific and Industrial Research Organisation, Hobart.

Gaichas, S. (2008) A context for ecosystem-based fishery management: developing concepts of ecosystems and sustainability. *Marine Policy* 32:393-401.

Garcia, S., and de Leiva Moreno, I. (2003) Global overview of marine fisheries in *Responsible Fisheries in the Marine Ecosystem.* Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

Garcia, S., and Grainger, R.(2005) Gloom and doom? The future of marine capture fisheries. *Philosophical Transactions of the Royal Society of London Series B Biological Sciences* 360 (1453): 21-46.

Gans, J., King, S., and Mankiw, N. (1999) *Principles of microeconomic*s. Harcourt Brace and Company, Australia.

Gibbs, M. (2009) Resilience: what is it and what does it mean for marine policy makers? *Marine Policy* 33:322-331.

Glasby, T. and Creese, R. (2007) Invasive marine species management and research in *Marine Ecology.* Eds. Connell, S. and Gillanders, B.Oxford University Press, Melbourne, Australia.

Goni, R. (2000) Fisheries effects on ecosystems in *Seas at the millennium: an environmental evaluation.* Ed. Sheppard, C. Elsevier Science, New York.

Grafton, R. (2005) Social capital and fisheries governance. *Ocean and Coastal Management* 48:753-766.

Gray, J. (1997) Marine biodiversity: patterns, threats and conservation needs. *Biodiversity and Conservation* 6:153-175.

Groenfeldt, D. (2003) The future of indigenous values: cultural relativism in the face of economic development. *Futures* 35:917-929.

Gunderson, L. (2000) Ecological resilience: in theory and application. *Annual Review Ecological Systems* 31:425-439.

Hall, S. (1999) *The effects of fishing on marine communities.* Blackwell Science, Oxford.

Hamond, L., and Synnot, R. Eds. (1994) *Marine biology.* Longman Cheshire Pty. Ltd., Melbourne, Australia.

Hanna, S. (1999) From single species to biodiversity: making the transition in fisheries management. *Biodiversity and Conservation*. 8:45-54.

Hanna, S. and Jentoft, S. (1996) Human use of the natural environment: an overview of social and economic dimensions in *Rights to nature: ecological, economic, and political principles of institutions for the environment.* Eds. Karl-Goran, M. Karl-Goran,, Hanna. S., Folke, C., and Maler, K. Techncial editor Jansson, A. Island Press, Washington D.C., California.

Hardin, G. (1968) The tragedy of the commons. *Science* 13(162):1243-1248.

Harrison, P. and Booth, D. (2007) Coral reefs: naturally dynamic and increasingly disturbed ecosystems in *Marine Ecology.* Eds. Connell, S. and Gillanders, B. Oxford University Press, Melbourne, Australia.

Hein, L., Koppen, K., de Groot, R., van Ierland, E. (2006) Spatial scale, stakeholders and the valuation of ecosystem services. *Ecological Economics* 57:209-228.

Holling, C. and Gunderson, L. (2002) Resilience and adaptive cycles in *Panarchy.* Island Press, Washington, USA.

Holling, C., Gunderson, L. and Peterson, G.(2002) Sustainability and panarchies in *Panarchy.* Island Press, Washington, USA.

Holmlund, C., and Hammer, M. (1999) Ecosystem services generated by fish populations. *Ecological Economics* 29:253-268.

Hughes, J. and Goodall, B. (1992) Marine Pollution in *Environmental issues in the 1990s*. Eds. Mannion, A, and Bowlby, S. John Wiley and Sons, New York.

Jensen, H. (2006) Changes in seafood consumer preference patterns and associated changes in risk exposure. *Marine Pollution Bulletin* 53:591-598.

Jentoft, S. (2000) The community: a missing link of fisheries management. *Marine Policy* 24:53-59.

Kaiser, M., and Jennings, S. (2002) Ecosystem effects of fishing in *Handbook of fish biology and fisheries Volume 2 Fisheries.* Eds. Hart, P., and Reynolds, J., Blackwell Science Ltd., Oxford, UK.

Kaiser, M., Attril, M., Jennings, S., Thomas, D., Barnes, D., Brierley, A., Polunin, N., Raffaelli, D., and Williams P. (2005) *Marine ecology: processes, systems and impacts.* Oxford University Press, Oxford.

Kaplan, I., and McCay, B. (2004) Cooperative research, co-management and social dimension of fisheries science and management. *Marine Policy* 28:257-258.

Karlson, R. (1999) *Dynamics of coral communities population and community biology*. Series Volume 23. Kluewer Academic Publishers, Dordrecht, The Netherlands.

Kay, R., and Alder, J. (2005) *Coastal planning and management.* Taylor and Francis, Abingdon, Oxon, UK.

Keating, M. (2000) The Pressure for change in *The future of governance.* Eds. Davis, G., and Keating, M. Allen and Unwin, St Leonards, NSW, Australia.

Kenchington, E. (2003) The effects of fishing on species and genetic diversity in *Responsible fisheries in the marine ecosystem.* Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

King, M., (2007) *Fisheries biology, assessment and management.* Fishing News Books a Division of Blackwell Science Ltd., Oxford, UK.

Kooiman, J., and Bavinck, M. (2005) The governance perspective in *Fish for life: interactive governance for fisheries.* Eds. Kooiman, J., Bavinck, M., Jentoft, S., and Pullin, R. MARE Publication Series No.3. Amsterdam University Press, Amsterdam.

Lalli, C. M. and Parsons, T. R. (1993) *Biological oceanography: an introduction.* Pergamon Press, Oxford, England.

Levinton, J. (1995) *Marine Biology: function, biodiversity, ecology.* Oxford University Press Inc., Oxford, UK.

Lehtonen, M, (2004) The environmental–social interface of sustainable development: capabilities, social capital, institutions. *Ecological Economics* 49:199– 214.

Levin, S., and Lubchenco, J. (2008) Resilience, robustness, and marine ecosystem-based management. *BioScience* 58(1):27-32.

Limburg, K., O'Neill, R., and Costanza, S. (2002) Complex systems and valuation. *Ecological Economics* 41:409-420.

Link, J. (December 2000) Fisheries management in an ecosystem context, what does this mean, what do we want, and can we do it? in *Proceedings of the 6th NMFS Stock Assessment Workshop (NSAW 28-30 March, 2000, Seattle, Washington. Incorporating Ecosystem Considerations into Stock Assessments and Management advice: what are the pros and cons of going beyond single species?* Prepared by the National Marine fisheries Service Ed. Mace, P. National Marine fisheries Services, USA.

Liu, Y., and Sumaila, U. (2008) Can farmed salmon production keep growing? *Marine Policy* 32:497-504.

Maguire, J., Sissenwine, M., Grainger, R., and Garcia, S. (2006) *The state of world highly migratory, straddling and other high seas fishery resources and associated species.* FAO Fisheries Technical Paper 495. FAO, Rome.

Mahon, R., McConney, P., and Roy, R. (2008) Governing fisheries as complex adaptive systems. *Marine Policy* 32:104-112.

Majkowski, J.(2005) Tuna and tuna-like species in *Review of the state of the world marine fishery resources.* FAO Fisheries Technical paper 457. FAO, Rome.

Mangel, M., Talbot, L., Meffe, G., Agardy, T., Alverson, D., Barlow, J., Botkin, D., Budowski, G., Clark, T., Cooke, J., Crozier, R., Dayton, P., Elder, D., Fowler, C., Funtowicz, S., Giske, J., Hofman, R., Holt, S., Kellert, S., Kimball, L., Ludgwig, D., Magnusson, K., Malayang III, B., Mann, C., Norse, E., Northridge, S., Perrin, W., Perrings, C., Peterman, R., Rabb, G., Regier, H., Reynolds III, J., Sherman, K., Sissenwine, M., Smith, T., Starfield, A., Taylor, R., Tillman, M., Toft, C., Twiss Jr, J., Wilen, J., and Young, T. (1996) Principles for the conservation of wild living resources. *Ecological Applications* 6 (2):338-362.

Mann, K. and Lazier, J. (1996) *Dynamics of marine ecosystems: biological-physical interactions in the oceans.* Second edition. Blackwell Sciences Inc., Oxford, UK.

Marchal, P., Anderson, B., Caillart, B., Eigaard, O., Guyader, O., Hovgaard, H., Iriondo, A., Le Fur, F., Sacchi, J., and Santurun, M. (2006) Impact of technological creep on fishing effort and fishing mortality, for a selection of European fleets. *ICES Journal of Marine Science* 64:192-209.

Mardle, S., and Pascoe, S. (2002) Modelling the effects of trade-offs between long and short-term objectives in fisheries management. *Journal of Environmental Management* 65:49-62.

Martha, K., Jones, M., Fitzgerald, D., Sale, P. (2002) Comparative ecology of marine fish communities in *Handbook of fish biology and fisheries Volume 1 Fish Biology.* Eds.Hart, P., and Reynolds J. Blackwell Science Ltd., Oxford, UK.

Mathew, S. (2003) Small-scale fisheries perspectives on an ecosystem-based approach to fisheries management in *Responsible fisheries in the marine ecosystem.* Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

Mayer, A. (2008) Strengths and weaknesses of common sustainability indices for multidimensional systems. *Environment International* 34:277-291.

McGoodwin, James R. (1990) *Crisis in the world's Fisheries: people, problems, and policies.* Stanford University Press Stanford California.

McKay, B., Mulvaney, K., and Thorne-Miller, B. (2010) *Danger at sea: our changing Ocean* SeaWeb, viewed 10 February 2010 <http://www.seaweb.org/resources/reports.php>

Meffe, G. and Carroll, C. (1994) *Principles of conservation biology.* Sinauer Associates, Inc. Sunderalnd, Massachusetts.

Newby, J., Gooday, P., and Elliston, L (2004) *Structural adjustments in Australian fisheries.* Australian Bureau of Agriculture and Resource Economics Report 04.17. Australian Bureau of Agriculture and Resource Economics, Canberra, Australia.

Nybakken, J. (2001) *Marine biology: an ecological approach.* Benjamin Cummings an imprint of Addison Wesley Longman Inc., San Francisco, CA.

Nystrom, M. and Folke, C. (2001) Spatial resilience of coral reefs *Ecosystems* 4:406-417.

Oosterveer, P. (2008) Governing global fish provisioning: ownership and management. *Ocean and Coastal Management* 51:797-805.

Open University (1989) *Seawater its composition properties and behaviour.* Open University, Walton Hall, Milton Keynes, UK. and Pergamon Press Plc., Headington Hill Hall, Oxford, UK.

Open University (1994) *Waves, tides and shallow-water processes.* Open University, Walton Hall, Milton Keynes, UK. and Elsevier Science Ltd., Oxford, UK.

Open University (1995) *Ocean circulation.* Open University, Walton Hall, Milton Keynes, UK. and Butterworth-Heinemann, Oxford, UK.

Parsons, T. and Harrison, P. (2000) Introduction in *Fisheries oceanography: an integrative approach to fisheries ecology and management.* Eds. Harrison, P. and Parsons, T. Fish and Aquatic Resources Series No. 4. Blackwell Science, Oxford, UK.

Pauly, D., Christensen, V., Dalsgaard, J., Froese, R., and Torres Jr. F. (1998) Fishing down marine food webs. *Science* 279:860-863.

Peterson, H. and Lubchenco, J. (1997) Marine Ecosystem Services in *Nature's services: societal dependence on natural ecosystems.* Ed. Daily, G. Island Press, Washington, DC.

Pittock, B. (2003) *Climate change: an Australian guide to the science and potential impacts.* Australian Greenhouse Office, Canberra, Australia.

Richardson, K. (2003) Anthropogenically induced changes in the environment: effect on fisheries in *Responsible fisheries in the marine ecosystem.* Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

Roach, C. (2000) Stewards of the sea: a model for justice? in *Just fish: ethics and Canadian marine fisheries.* Eds. Coward, H., Ommer, R., and Pitcher, T. Social and

Economic Papers No. 23. Institute of Social and Economic Research, Memorial University of Newfoundland, Canada.

Rosenberg, A. (2003) Multiple uses of marine ecosystems in *Responsible fisheries in the marine ecosystem.* Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

Roth, W., and Rosenthal, H. (2006) Fisheries and aquaculture industries involvement to control product health and quality safety to satisfy consumer driven objectives on retail markets in Europe. *Marine Pollution Bulletin* 53:599-605.

Sabine, C., Feely, R., Gruber, N., Key, R., Lee, K., Bullister, J., Wanninkhof, R., Wong, C., Wallace, D., Tilbrook, B., Millero, F., Peng, T., Kozyr, A., Ono, T., Rios, A. (2004) The oceanic sink for anthropogenic CO_2. *Science* 305:367 – 371.

Schirmer, J. (2005) *ESD Reporting and Assessment Subprogram: a social assessment handbook for use by Australian fisheries managers in ESD assessment and monitoring.* Final Report FRDC Project 2003/056. FRDC, Canberra, ACT.

Sissenwine, M. and Mace, P. (2003) Governance for responsible fisheries: an ecosystem approach in *Responsible fisheries in the marine ecosystem.* Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

Srinivassan, U., Carey, S., Hallstein, E., Higgins, T., Kerr, A., Koteen, L., Smith, A., Watson, R., Harte, J., and Norgaard, R. (2008) The debt of nations and the distribution of ecological impacts from human activities. *PNAS* 105(5):1768-1773.

Stonecash, R., Gans, J., King, S., and Mankiw, N. (1999) *Principles of macroeconomics.* Harcourt, Australia.

Suchanek, T.(1993) Oil impacts on marine invertebrate populations and communities. *American Zoologist* 33:510-523.

Suchanek, T. (1994) Temperate coastal marine communities: biodiversity and threats. *American Zoologist* 34:100-114.

Sutinen, J., Clay, P., Dyer, C., Edwards, S., Gates, J., Grigalunas, T., Hennessey, T., Juda, L., Kitts, A., Logan, P., Poggie Jr, J., Rountree, B., Stienback, S., Thunberg, E., Upton, H., Walden, J. (2005) A framework for monitoring and assessing socioeconomics and governance of large marine ecosystems in *Sustaining large marine ecosystems: the human dimension*. Eds. Henessey, T. and Sutinen, J. Large Marine Ecosystems Series No.13. Elsevier B. V, Amsterdam, The Netherlands.

Symes, D., and Phillipson, J. (2009) Whatever became of social objectives in fisheries policy? *Fisheries Research* 95:1-5.

Tegner, M., and Dayton, P. (2000) Ecosystem effects of fishing in kelp forest communities *ICES Journal of Marine Science* 57: 579–589.

Tilman, D. (1997) Biodiversity and ecosystem functioning in *Nature's services: societal dependence on natural ecosystems.* Ed. Daily, G. Island Press, Washington, DC.

Thorne-Miller, B., and Catena, J. (1991) *The Living Ocean: understanding and protecting marine biodiversity.* Island Press, Washington, DC.

United Nations Environment Programme (UNEP) (2007) *Global environment outlook GEO4 environment for development.* United Nations Environment Programme, Nairobi, Kenya.

Valdemarsen, J., and Suuronen, P. (2003) Modifying fishing gear to achieve ecosystem objectives in *Responsible fisheries in the marine ecosystem.* Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

Voice, M., Harvey, N., and Walsh, K. (2006) V*ulnerability to climate change of Australia's costal zone: analysis of gaps in methods, data and system thresholds.* Report to the Australian Greenhouse Office. Department of the Environment and Heritage, Canberra, ACT.

Walker, B., Anderies, J., Kinzig, A., and Ryan, P. (2006) Exploring resilience in social-ecological systems through comparative studies and theory development: introduction to the special issue. *Ecology and Society* 11(1): 12.

Whitmarsh, D., Pipitone, C., Badalamenti, F., and D'Anna, G. (2003) The economic sustainability of artisanal fisheries: the case of the trawl ban in the Gulf of Castellammare, NW, Sicily. *Marine Policy* 27:489-497.

World Wide Fund for Nature WWF/IUCN (1998) *Creating a sea change*. Banson Production, London.

Chapter 4

Allison, E. (2001) Big laws, small catches: global ocean governance and the fisheries crisis. *Journal of International Development* 13:933-950.

Arkema, K., Abramson, S., and Dewsbury, B. (2006) Marine ecosystem-based management: from characterization to implementation. *Frontiers Ecology Environment* 4(10):525-532.

Aqorau, T. (2003) Obligations to protect marine ecosystems under international conventions and other legal instruments in *Responsible fisheries in the marine ecosystem*, Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

Atkinson, A., Siegel, V., Pakhomov, E., Jessopp, M., and Loeb, V. (2009) A re-appraisal of the total biomass and annual production of Antarctic krill. *Deep-sea Research* 56:727-740.

Baker, M., Bett, B., Billett, D. and Rogers, A. (2001) The status of natural resources on the high seas in *The status of natural resources on the high-seas.* WWF/IUCN, Gland, Switzerland.

Bavinck, M., Chuenpagdee, R., Diallo, M., van der Hiejden, P., Kooiman , J., Mahon, R., and Williams, S. (2005) *Interactive fisheries governance: a guide to better practice.* Eburon Academic Publishers, Delft, The Netherlands.

Bellamy, J., Walker, D., McDonald, G., and Syme, G. (2001) A systems approach to the evaluation of natural resource management initiatives. *Journal of Environmental Management* 63:407-423.

Berghofer, A., Wittmer, H., and Rauschmayer (2008) Stakeholder participation in ecosystem-based approaches to fisheries management: a synthesis from European research projects. *Marine Policy* 32:243-253.

Bridgman, P. and Davis, G. (1998) *Australian policy handbook.* Allen and Unwin, St Leonards NSW, Australia.

Butterworth, D., Cochrane, K., Dunn, M., and Fox, C. (2004) Report of Discussion Group 1 International approaches to management of shared stocks: fisheries, management and external driver issues in *Management of shared fish stocks.* Eds. Payne, A., O'Brien, C. and Rogers, S. Blackwell Publishing Ltd., Oxford, UK.

Charles, A. (2001) *Sustainable fishery systems.* Blackwell Science, Oxford.

Christensen, N., Bartuska, A., Brown, J., Carpenter, S., D'Antonio, C., Francis, R., Franklin, J., MacMahon, J., Noss, R., Parsons, D., Peterson, C., Turner, M., and Woodmansee, R. (1996) The Report of the Ecological Society of America Committee on the Scientific Basis for Ecosystem Management. *Ecological Applications* 6 (3):665-691.

Chuenpagdee, R., and Jentoft, S. (2007) Step zero for fisheries co-management: what precedes implementation. *Marine Policy* 31:657-668.

Chuenpagdee, R., Degnbol, P., Bavinck, M., Jentoft, S., Johnson, D., Pullin, R., and Williams, S. (2005) Challenges and concerns in capture fisheries and aquaculture in *Fish for life: interactive governance for fisheries.* Eds. Kooiman, J., Bavinck, M., Jentoft, S., and Pullin, R. MARE Publication Series No.3. Amsterdam University Press, Amsterdam.

Cicin-Sain, G., and Belfiore, S. (2005) Linking marine protected areas to integrated coastal and ocean management: a review of theory. *Ocean and Coastal Management* 48:847-868.

Cicin-Sain, G., and Knecht, R (1998) *Integrated coastal and ocean management: concepts and practices.* Island Press, Washington, USA.

Clark, B., and Hemmings, A. (2001) Problems and prospects for the Convention on the Conservation of Antarctic Marine Living Resources twenty years on. *Journal of International Wildlife Law and Policy* 4:47-62.

Cochrane, K. (1999) Complexity in fisheries and limitations in increasing complexity of fisheries management. *ICES Journal of Marine Science* 56:917-926.

Cole, H. (2003) Contemporary challenges: globalisation, global interconnectedness and that 'there are *not* plenty more fish in the sea'. Fisheries, governance and globalisation: is there a relationship? *Ocean and Coastal Management* 46:77-102.

Constable, A., de la Mare, W., Agnew, D., Everson, I., and Miller, D. (2000) Managing fisheries to conserve the Antarctic marine ecosystem: practical implementation of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR). *ICES Journal of Marine Science* 57:778–791.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (2010a) *What is CITES?* viewed 4 February 2010 <http://www.cites.org/eng/disc/what.shtml>.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (2010b) *How CITES works,* viewed 4 February 2010 <http://www.cites.org/eng/disc/how.shtml>.

Costanza, R., Fransico, A., Antunes, P., van den Belt, M., Boesch, D., Boersma, D., Catarino, F., Hanna, S., Limburg, K., Low, B., Molitor, M., Pereira, J., Rayner, S., Santos, R., Wilson, J., and Young, M. (1999) Ecological economics and sustainable governance of the oceans. *Ecological Economics* 31:171-187.

Costanza, R., Low, B., Ostram, E., and Wilson, J. (2001) Ecosystems and human systems: a framework for exploring the linkages in *Institutions, ecosystems, and sustainability.* Eds. Costanza, R., Low, B., Ostram, E., and Wilson, J. Lewis Publisher an imprint of CRC Press LLC, Boca Raton, USA.

Davis, G., and Keating, M. (2000) *The future of governance: policy choices.* Allen and Unwin, St Leaonards, NSW, Australia.

Department of Primary Industries (2007) *Victorian fisheries consultative arrangements review: discussion paper.* Fisheries Victoria Management Report Series. Fisheries Management Paper No. 51. Department of Primary Industries, Victoria, Australia.

Dryzek, J. (1992) Ecology and discursive democracy: beyond liberal capitalism and the administrative state. *Capitalism Nature Socialism,* 3(2):18-42.

Edeson, W. (2005) A brief introduction to the principal provisions of the international legal regime governing fisheries in the EEZ in *A sea change: the exclusive economic zone and governance institutions for living marine resources.* Eds. Ebbin, S., Hoel, A., and Sydnes, A. Springer, Dordrecht, The Netherlands.

Ekstrom, J., Young, O., Gaines, S., Gordon, M., and McCay, J. (2009) A tool to navigate overlaps in fragmented ocean governance. *Marine Policy* 33:532-535.

Ecosystem Principles Advisory Panel (EPAP) (1999) *Ecosystem-based fishery management.* A report to Congress by EPAP. National Marine Fisheries Services, Silver Spring, Maryland.

Folke, C., Berkes, F., and Colding, J. (2000) Ecological practices and social mechanisms for building resilience and sustainability in *Linking social and ecological systems: management practices and social mechanisms of building resilience.* Eds. Berkes, F., Folke, C., and Colding, J. Cambridge University Press, Cambridge, UK.

Food and Agricultural Organisation (FAO) of the United Nations (2003) *Fisheries management. 2. The ecosystem approach to fisheries.* FAO Technical Guidelines for responsible fisheries No.4, Supplement 2. FAO, Rome.

Friedheim, R. (1999) Ocean governance at the millennium: where we have been – where we should go. *Ocean and Coastal Management* 42:747-765.

Garcia, S. and Charles, A. (2008) Fishery systems and linkages: implications for science and governance. *Ocean and Coastal Management* 51:505-527.

Garcia, S., and Hayashi, M. (2000) Division of the oceans and ecosystem management: a contrastive spatial evolution of marine fisheries governance. *Ocean and Coastal Management* 43:445-474.

GESAMP (Joint group of Experts on the scientific aspects of marine environmental protection) and Advisory Committee on Protection of the Sea (2001) *Protecting the oceans from land-based activities: land based sources and activities affecting the quality and uses of the marine, coastal and associated freshwater environment.* Ed. Lean, G. Report and Studies GESMAP No. 71. United Nations Environment Programme, The Hague.

Grafton, R., Kompas, T., McLoughline, R., and Rayns, N. (2007) Benchmarking for fisheries governance. *Marine Policy* 31:470-479.

Grafton, R., Hilborn, R., Ridgeway, L., Squires, D., Williams, M., Garcia, S., Groves, T., Joseph, J., Kelleher, K., Kompas, T., Libecap, G., Lundin, C., Makino, M., Matthiasson, T., Mcloughlin, R., Parma, A., Martin, G., Satia, B., Schmidt, C., Tait, M., and Zhang, L. (2008) Positioning fisheries in a changing world. *Marine Policy* 32:630-634.

Griffis, R., and Kimball, K. (1996) Ecosystem Approaches to coastal and ocean stewardship. *Ecological Applications* 6(3):708-712.

Grumbine, R. (1994) What is ecosystem management. *Conservation Biology* Volume 8 (1): 27-38.

Hanna, S. (1998) Institutions for marine ecosystems: economic incentives and fishery management. *Ecological Applications Supplement* 8(1):170-174.

Hanna, S. (1999) Strengthening governance of ocean fishery resources. *Ecological Economic* 31:275-286.

Harding, R. (1998). *Environmental decision-making: the roles of scientists, engineers and the public.* The Federation Press, Sydney.

Hartje, V., Klaphake, A., and Schliep, R. (2003) *The international debate on the ecosystem approach: critical review, international actors, obstacles and challenges.* BfN-Skrpten 80. Bundesmat fur Naturschutz (BfN), Federal Agency for Nature Conservation, Germany.

Haward, M. (2004) IUU fishing: contemporary practice in *Oceans management in the 21st Century: institutional frameworks and responses.* Eds. Elferink, A., and Rothwell, D. Martinus Nijhoff Publishers, Boston.

Hoel, A., and Kvalvik, I. (2006) The allocation of scarce natural resources: the case of fisheries. *Marine Policy* 30:347–356.

Hoel, A., Sydnes, A., and Ebbin S. (2005) Ocean governance and institutional change in *A sea change: the exclusive economic zone and governance institutions for living marine resources.* Eds. Ebbin, S., Hoel, A., and Sydnes, A. Springer, Dordrecht, The Netherlands.

Hundloe, T. (2002) *Valuing fisheries: an economic framework* University of Queensland Press, St. Lucia, Queensland.

Hunt, C. Concern for southern ocean fish stocks and bird populations. *Marine Policy* 30:357-359.

Jentoft S. (2004) Institutions in fisheries: what they are, what they do, and how they change. *Marine Policy* 28:137-149.

Jentoft, S. (2005) Institutions for fisheries governance: an introduction in *Fish for life: interactive governance for fisheries.* Eds. Kooiman, J., Bavinck, M., Jentoft, S., and Pullin, R. MARE Publication Series No.3. Amsterdam University Press, Amsterdam.

Johnson, D., Thorpe, A., Bavinck, M. and Kulbicki, M. (2005) Links in the fish chain in *Fish for life: interactive governance for fisheries.* Eds. Kooiman, J., Bavinck, M., Jentoft, S., and Pullin, R. MARE Publication Series No.3. Amsterdam University Press, Amsterdam.

Kay, R. and Alder, J. (2005) *Coastal planning and management.* Taylor and Francis, an imprint of the Taylor and Francis Group, Oxon, UK.

Kim, J. (2004) Regime interplay: the case of biodiversity and climate change. *Global Environmental* Change 14:315-324.

Kimball, L.A. (2001*) Intergovernmental ocean governance: using international law and organizations to manage marine resources sustainably.* IUCN, Gland, Switzerland.

Kolody, D., Polacheck, T., Davies, C. (2008) Salvaged pearls: lessons learned from a floundering attempt to develop a management procedure for Southern Bluefin Tuna. *Fisheries Research* 94:339-350.

Kooiman, J., and Bavinck, M. (2005) The governance perspective in *Fish for life: interactive governance for fisheries.* Eds. Kooiman, J., Bavinck, M., Jentoft, S., and Pullin, R. MARE Publication Series No.3. Amsterdam University Press, Amsterdam.

Kooiman, J., and Jentoft, S. (2005) Hard choices and values in *Fish for life: interactive governance for fisheries.* Eds. Kooiman, J., Bavinck, M., Jentoft, S., and Pullin, R. MARE Publication Series No.3. Amsterdam University Press, Amsterdam.

Korn, H., Schliep, R., and Stadler, J. (2003). *Report of the international workshop on the further development of the ecosystem approach.* BfN-Skrpten 78. Bundesmat fur Naturschutz (BfN), Federal Agency for Nature Conservation, Germany.

Kotchen, M., and Young, O. (2007) Meeting the challenges of anthropocene: towards a science of coupled human-biophysical systems. *Global Environmental Change* 17:149-151.

Lackey, R., (1998) Seven pillars of ecosystem management. *Landscape and Urban Planning* 40:21-30.

Langley, A., Wright, A., Hurry, G., Hampton, J., Aqorua, T., and Rodwell, L. (2009) Slow steps towards management of the world's largest tuna fishery. *Marine Policy* 33:271-279.

Linkov, I., Satterstrom, F., Kiker, G., Batchelor, C., Bridges, T., and Ferguson, E. (2006) From comparative risk assessment to multi-criteria decision analysis and adaptive management: recent developments and applications. *Environment International* 32:1072-1093.

Lugten, G. (1999) *A review of measures taken by regional marine fisheries bodies to address contemporary fishery issues.* FOA Fisheries Circular Paper No. 940. FAO, Rome.

Macfadyen, G., and Huntington, T. (2004) *Human capacity development in fisheries.* FAO Fisheries Circular No. 1003. FAO, Rome.

Mahon, R., Bavinck, M., and Roy, R. (2005) Governance in action in *Fish for life: interactive governance for fisheries.* Eds. Kooiman, J., Bavinck, M., Jentoft, S., and Pullin, R. MARE Publication Series No.3. Amsterdam University Press, Amsterdam.

Mangel, M., Talbot, L., Meffe, G., Agardy, T., Alverson, D., Barlow, J., Botkin, D., Budowski, G., Clark, T., Cooke, J., Crozier, R., Dayton, P., Elder, D., Fowler, C., Funtowicz, S., Giske, J., Hofman, R., Holt, S., Kellert, S., Kimball, L., Ludgwig, D., Magnusson, K., Malayang III, B., Mann, C., Norse, E., Northridge, S., Perrin, W., Perrings, C., Peterman, R., Rabb, G., Regier, H., Reynolds III, J., Sherman, K., Sissenwine, M., Smith, T., Starfield, A., Taylor, R., Tillman, M., Toft, C., Twiss Jr, J., Wilen, J., and Young, T. (1996) Principles for the conservation of wild living resources. *Ecological Applications* 6 (2):338-362.

McCay, B. (1996) Common and private concerns in *Rights to nature: ecological, economic, and political principles of institutions for the environment.* Eds. Karl-Goran, M., Hanna. S., Folke, C., and Maler, K. Technical editor Jansson, A. Island Press, Washington DC., California.

Meadowcroft, J. (2002) Politics and scale: some implications for environmental governance. *Landscape and Urban Planning* 61:169-179.

Meadowcroft, J. (2007) National sustainable development strategies: features, challenges and reflexivity. *European Environment* 17:152-163.

Michel, D. (2009) Foxes, hedgehogs, and greenhouse governance: knowledge, uncertainty, and international policy-making in a warming world. *Applied Energy* 86:258-264.

Molenaar, E. (2001) CCAMLR and southern ocean fisheries. *The International Journal of Marine and Coastal Law* 16(3)465-499.

Munro, G., Willman, R. and Cochrane, L. (2004) On management of shared fish stocks: critical issues and international initiatives to address them in *Management of shared fish stocks.* Eds. Payne, A., O'Brien, C. and Rogers, S. Blackwell Publishing Ltd., Oxford, UK.

Newell, B., Crumley, C., Hassan, N., Lambin, E., Phal-Wostl, C., Underdal, A., and Wasson, R. (2005) A conceptual template for intergrative human-environment research. *Global Environmental Change* 15:299-307.

Pascual-Fernandez, J., Jentoft, S., Kooiman, J., and Trinidad, A. Institutional linkages in *Fish for life: interactive governance for fisheries.* Eds. Kooiman, J., Bavinck, M., Jentoft, S., and Pullin, R. MARE Publication Series No.3. Amsterdam University Press, Amsterdam.

Paavola, J. (2007) Institutions and environmental governance: a reconceptualisation *Ecological Economics* 63:93-103.

Phal-Wostl, C. (2007) The implications of complexity for integrated resources management. *Environmental Modelling and Software* 22:561-569.

Pomeroy, R., and Berkes, F. (1997) Two to tango: the role of government in fisheries co-management. *Marine Policy* Vo. 21(5): 465-480.

Potts, T., and Haward, M. (2007) International trade eco-labelling, and sustainable fisheries: recent issues, concepts and practices. *Environment, Development and Sustainability* 9:91-106.

Rayner, S. (1999) Mapping institutional diversity for implementing the Lisbon principles. *Ecological Economics* 31:259-274.

Reid, K., Croxall, J., Briggs, D., and Murphy, E. (2005) Antarctic ecosystem monitoring: quantifying the response of ecosystem indicators to variability in Antarctic krill. *ICES Journal of Marine Science* 62:366-373.

Ruckes, E. (2000) Evolution of the international regulatory frameworks governing international trade in fishery products in *Micro behavior and Macro results: Proceedings of the Tenth Biennial Conference of the International Institute of Fisheries Economics and Trade.* International Institute of Fisheries Economics and Trade, Oregon State University.

Rudd, M. (2004) An institutional framework for designing and monitoring ecosystem-based fisheries management policy experiments. *Ecological Economics* 48:109-124.

Sainsbury K., Haward M., Kriwoken L., Tsamenyi M., and Ward T. (1997) *Multiple Use Management in the Australian marine environment: principles, definitions and elements.* Oceans Planning and Management Issues Paper 1. A Report commissioned by Environment Australia June 1997. Department of the Environment, Canberra, ACT.

Sainsbury, K., Punt, A., and Smith, A. (2000) Design of operational management strategies for achieving fishery ecosystem objectives. *ICES Journal of Marine Science* 57:731–741.

Scanlon, J., and Burhenne-Guilmin, F. (2004) Executive summary in *International environmental governance: an international regime for protected areas.* Eds. Scanlon, J., and Burhenne-Guilmin, F. IUCN Environmental Policy and Law Paper No. 49. IUCN, Gland, Switzerland.

Sen, S., and Nielsen, J. (1996) Fisheries co-management a comparative analysis. *Marine Policy* 20(5):405-418.

Sissenwine, M. and Mace, P. (2003) Governance for Responsible Fisheries: an ecosystem approach in *Responsible fisheries in the marine ecosystem.* Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

Smith, A., Sainsbury, K., and Stevens, R. (1999) Implementing effective fisheries-management systems – management strategy evaluation and the Australian partnership approach. *ICES Journal of Marine Science* 56:967-979.

Suarez de Vivero, J., Mateos, J., del Corral, D. (2008) The paradox of public participation in fisheries governace. The rising number of actors and the devolution of process. *Marine Policy* 32:319-325.

Sutinen, J. and Soboil, M. (2003) The performance of fisheries management systems and ecosystem challenge in *Responsible fisheries in the marine ecosystem.* Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

Swan, J. (2000) *Regional fishery bodies and governance: issues, action and future directions.* FAO Fisheries Circular No. 959. FAO, Rome.

Symes, D. (2006) Fisheries governance: a coming of age for fisheries social science. *Fisheries Research* 81:113-117.

Symes, D. (2007) Fisheries management and institutional reform: a European perspective. *ICES Journal of Marine Science* 64:779 - 785.

Syndes, K. (2005) Regional Fisheries Organisations and international fisheries governance in *A sea change: the exclusive economic zone and governance institutions for living marine resources.* Eds. Ebbin, S., Hoel, A., and Sydnes, A. Springer, Dordrecht, The Netherlands.

Sydnes, A., Hoel, A., and Ebbin, S. (2005) Changing seas, changing institutions: charting new courses into the future in *A sea change: the exclusive economic zone and governance institutions for living marine resources.* Eds. Ebbin, S., Hoel, A., and Sydnes A. Springer, Dordrecht, The Netherlands.

Thorne-Miller, B., and Catena, J. (1991) *The living ocean: understanding and protecting marine biodiversity.y* Island Press, Washington, DC.

United Nations (1992) *Convention on Biological Diversity*.

United Nations Environment Programme (UNEP) (2010a) *The Regional Seas Programmes,* viewed 4 February 2010 <http://www.unep.org/regionalseas/programmes>

United Nations Environment Programme (UNEP) (2010b) *New global strategy,* viewed 4 February 2010 <http://www.unep.org/regionalseas/about/strategy/default.asp>.

Walters, C. and Holling, C. (1990) Large-scale management experiments and learning by doing *Ecology* 71(6):2060-2068.

Ward, T., Tarte, D., Hegerl, E., Short, K. (2002) *Policy proposals and operational guidance for Ecosystem-Based Management of marine capture fisheries.* World Wide Fund for Nature (WWF) Australia.

Waugh, S., Baker., G., Gales, R., and Croxall, J. (2008) CCAMLR process of risk assessment to minimise the effect of longline fishing mortality on seabirds. *Marine Policy* 32:442-454.

Weller, P. (2000) Introduction: in search of governance in *The future of governance.* Eds. Davis, G., and Keating, M. Allen and Unwin, St Leonards, NSW, Australia.

Westley, F. (2002) The devil in the dynamics: adaptive management on the front lines in *Panarchy.* Island Press, Washington, USA.

Willock, A., and Lack, M. (2006) *Follow the leader: learning from experience and best practice in regional fisheries management organizations.* WWWF International and TRAFFIC International, Gland, Switzerland.

World Trade Organisation (2010) *WTO documents*, viewed 4 February 2010 <http://www.wto.org/english/docs_e/docs_e.htm>.

World Trade Organisation (WTO) (2007) *Understanding the WTO.* Wold Trade Organisation, Geneva, Switzerland.

Young, O. (1998) Institutional uncertainties in international fisheries management. *Fisheries Research* 37:211-224.

Chapter 5

Agnew, D., Grieve, C., Orr, P., Parkes, G., and Barker, N. (2006) *Environmental benefits resulting from certification against MSC's principles and criteria for sustainable fishing.* MRAG UK Ltd. and Marine Stewardship Council, London.

Arnason, R. (2009) Fisheries management and operations research. *European Journal of Operational Research* 193:741-751.

Astles, K., Holloway, M., Steffe, A., Green, M., Ganassin, C., and Gibbs, P. An ecological method for qualitative risk assessment and its use in the management of fisheries in New South Wales, Australia. *Fisheries Research* 82:290-303.

Babcock, S., Pikitch, E., McAllister, M., Aposolaki, A., and Santora, C. (2005) A perspective on the use of spatialised indicators for ecosystem-based fishery management through spatial zoning. *ICES Journal of Marine Science* 62:469-476.

Barbier, E. (1992) *The nature of economic instruments: a brief overview.* The London Environmental Economics Centre, London.

Berghofer, A., Wittmer, H., and Rauschmayer, F. (2008) Stakeholder participation in ecosystem-based approaches to fisheries management: a synthesis from European research projects. *Marine Policy* 32:243-253.

Berkes, F., and Folke, C. (2000) Linking social and ecological systems for resilience and sustainability in *Linking social and ecological systems: management practices and social mechanisms for building resilience.* Eds. Berkes, F., Folke, C., and Colding, J. Cambridge University Press, Cambirdge, UK.

Boyd, H., and Charles, A. (2006) Creating community-based indicators to monitor sustainability of local fisheries. *Ocean and Coastal Management* 49:237-258.

Brady, M., and Waldo, S. (2009) Fixing problems in fisheries- integrating ITQs, CBM and MPAs in management. *Marine Policy* 33:258-263.

Bromley, D. (1991) *Environment and Economy: property rights and public policy.* Blackwell, Oxford, UK.

Brussard, P., Reed, J., and Tracy, C. (1998) Ecosystem management: what is it really? *Landscape and Urban Planning* 40:9-20.

Burgman, M. (2005) *Risks and decisions for conservation and environmental management.* Cambridge University Press, Cambridge U.K.

Butterworth, D., and Punt, A. (1999) Experiences in the evaluation and implementation of management procedures. *ICES Journal of Marine Science* 556:985-998.

Chaffe, C., Leadbitter, D., and Alders, E. (2003) Seafood evaluation, certification and consumer information in *Eco-labelling in fisheries: what is it all about?* Eds. Phillips, B., Ward, T., and Chaffee, C., Blackwell Science, Oxford, UK.

Charles, A. (2001) *Sustainable fishery systems.* Blackwell Science, Oxford.

Charles, A., and Wilson, L. (2009) Human dimensions of Marine Protected Areas. *ICES Journal of Marine Science* 66:6-15.

Cicin-Sain, B., and Belfiore, S. (2005) Linking marine protected areas to integrated coastal and ocean management: a review of theory. *Ocean and Coastal Management* 48:847-868.

Cicin-Sain, B., and Knecht, R (1998) *Integrated coastal and ocean management: concepts and practices.* Island Press, Washington, USA.

Cochrane, L. (2002) Fisheries management in *A fishery manager's guidebook: management measures and their application.* Ed. Cochrane, K., Fisheries Technical Paper No. 424. FAO, Rome.

Cooney, R. (2004) *The precautionary principle in biodiversity conservation and natural resource management: an issues paper for policy-makers, researchers and practitioners.* IUCN Policy and global Changes Series No. 2. IUCN, Gland, Switzerland.

Costanza, R. (2003) A vision of the future of science: reintegrating the study of humans and the rest of nature. *Futures* 35:651-671.

Costello, C., Gaines, S., and Lyham, J. (2008) Can catch shares prevent fisheries collapse? *Science* 321:1678-1681.

Curry, P., Shin, Y., Planque, B., Durant, J., Fromentin, J., Kramer-Schadt, S., Stenseth, N., Travers, M., and Grimm, V. (2008) Ecosystem oceanography got global change in fisheries. *Trends in Ecology and Evolution* 23:338-346.

Dankel, D., Skagen, D., and Ultang, O. (2008) Fisheries management in practice: review of 13 commercially important fish stocks. *Reviews in Fish Biology and Fisheries* 18:201-233.

Davis, D., and Gartside, D. (2001) Challenges for economic policy in sustainable management of marine natural resources. *Ecological Economics* 36:223-236.

Day, J. (2008) The need and practice of monitoring, evaluating and adapting marine planning and management- lessons form the Great Barrier Reef. *Marine Policy* 32:823-831.

Defeo, O., McClanahan, T, and Castilla, J. (2007) A brief history of fisheries management with emphasis on societal participatory roles in *Fisheries management: progress towards sustainability.* Eds. McClanahan, T., and Castilla, J. Blackwell Publishing Ltd., Oxford, UK.

Degnbol, O., Gislason, H., Hanna, S., Jentoft, S., Nielson, J., Sverdrup-Jensen, S., and Wilson, D. (2006) Painting the floor with a hammer: technical fixes in fisheries management. *Marine Policy* 30:534-543.

de la Mare, W. (2005) Marine ecosystem-based management as a hierarchical control system. *Marine Policy* 29:56-68.

Dichmont, C., Deng, A., Punt, A., Ellis, N., Venables, W., Kompas, T., Ye, Y., Zhou, S., and Bishop, J. (2008) Beyond biological performance measures in management strategy evaluation: bringing in economics and the effects of trawling on the benthos. *Fisheries Research* 94:238-250.

Douvre, F. (2008) The importance of marine spatial planning in advancing ecosystem-based sea use management. *Marine Policy* 32:762-771.

Ecosystem Principles Advisory Panel (EPAP) (1999) *Ecosystem-based Fishery Management.* A report to Congress by the EPAP. National Marine Fisheries Services, Silver Spring, Maryland.

Ehler, C. (2005) Integrating management of marine protected areas with coastal and ocean governance: principles and practices. *Ocean and Coastal Management* 48:843-846.

Essington, T. (2001) The precautionary approach in fisheries management: the devil is in the details. *Trend in Ecology and Evolution* 16(3):121-122.

Failing, L., Gregory, R., and Harstone, M. (2007) Integrating science and local knowledge
in environmental risk management: a decision-focused approach. *Ecological Economics* 64:47-60.

Fenichel, E., Tsao, J., Jones, M., and Hickling, G. (2008) Real options for precautionary fisheries management. *Fish and Fisheries* 9:121-137.

Fischer, J., Manning, A., Steffen, W., Rose, D., Daniell, K., Felton, A., Garnett, S., Gilna, B., Heinsohon, R., Lindenmayer, D., MacDonald, B., Mills, F., Newell, B., Reid, J., Robin, L., Sherren, K., and Wade, A. (2007) Mind the sustainability gap. *Trends in Ecology and Evolution* 22(12):621-624.

Foden, J., Rogers, S., and Jones, A. (2008) A critical review of approaches to aquatic environmental assessment. *Marine Pollution Bulletin* 56:1825-1833.

Food and Agricultural Organisation (FAO) of the United Nations (1995) *Code of Conduct for Responsible Fisheries.* FAO, Rome.

Food and Agricultural Organisation (FAO) of the United Nations (1999) *Indicators for sustainable development of marine capture fisheries.* FAO Technical Guidelines for Responsible Fisheries No. 8. FAO, Rome.

Food and Agricultural Organisation (FAO) of the United Nations (2003) *Fisheries management: the ecosystem approach to fisheries.* FAO Technical Guidelines for Responsible Fisheries 4 Supplement 2. FAO, Rome.

Food and Agricultural Organisation (FAO) of the United Nations (2005) *Guidelines for the ecolabelling of fish and fishery products from marine capture fisheries.* FAO, Rome.

Fulton, E., Smith, A., and Smith, D. (2007) *Alternative management strategies for the southeast Australian Commonwealth fisheries: Stage 2: Quantitative management strategy evaluation.* Commonwealth Scientific and Industrial Research Organisation, Hobart, Australia.

Garcia, S. and Cochrane, K. (2005) Ecosystem approach to fisheries: a review of implementation guidelines. *ICES Journal of Marine Science* 62:311-318.

Garcia, S., and de Leiva Moreno, I. (2003) Global overview of marine fisheries in *Responsible Fisheries in the marine ecosystem.* Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

Garcia, S., Zerbi, A. Aliaume C., Do Chi, T.,and Lasserre, G. (2003) *The Ecosystem Approach to Fisheries: issues, terminology, principles, institutional foundations, implementation and outlook.* FAO Fisheries Technical Paper 443. FAO, Rome.

Gibbs, M. (2007) Lesser-known consequences of managing marine fisheries using individual transferable quotas. *Marine Policy* 31:112-116.

Gislason, H., Sinclair, M., Sainsbury, K., and O'Boyle, R. (2000) Symposium overview: incorporating ecosystem objectives within fisheries management. *ICES Journal of Marine Science* 57:468-475.

Gonzalez-Laxe, F., (2005) The precautionary principle in fisheries management. *Marine Policy* 29:495-505.

Grafton, R., Kompas, T., McLoughlin, R., and Rayns, N. (2007) Benchmarking for fisheries governance. *Marine Policy* 31:470-479.

Greiner, R., Young, M., McDonald, D., and Brooks, M. (1997) *Australia's oceans policy: management instruments for marine resource allocation and use.* Oceans planning and management issues paper 2. Department of the Environment, Canberra, ACT.

Hanna, S. (1999) Strengthening governance of ocean and fishery resources. *Ecological Economics* 31:275-286.

Hanna, S., Folke, C., and Maler, R. (1996) Property rights and the natural environment in *Rights to nature: ecological, economic, cultural, and political principles of institutions for the environment.* Eds. Karl-Goran, M., Hanna**,** S., Folke**,** C., Mäler**,** K. Technical ed. Jansson, A. Beijer International Institute of Ecological Economics. Island Press, Washington DC.

Hardin, G. (1968) The tragedy of the commons. *Science* 13(162):1243-1248.

Hartje, V., Klaphake, A., and Schliep, R. (2003) *The international Debate on the Ecosystem Approach: critical review, international actors, obstacles and challenges.* BfN-Skrpten 80. Bundesmat fur Naturschutz (BfN), Federal Agency for Nature Conservation, Germany.

Hilborn, R. (2007) Defining success in fisheries and conflicts in objectives. *Marine Policy* 31:153-158.

Hilborn, R., Maguire, J., Parma, A., and Rosenberg, A. (2001) The precautionary approach and risk management: can they increase the probability of success in fishery management? *Canadian Journal of Fisheries and Aquatic Science* 58:99-107.

Hilborn, R., Stokes, K., Maguire, J., Smith, Tony, Botsford, L., Mangel, M., Orensanz, J., Parma, A., Rice, J., Bell, J., Cochrane, K., Garcia, S., Hall, S., Kirkwood, G., Sainsbury, K., Stefansson, G., and Walters, C. (2004) When can marine reserves improve fisheries management? *Ocean and Coastal Management* 47:197-205.

Hoel, A., and Kvalvik, I. (2006) the allocation of scarce natural resources: the case of fisheries. *Marine Policy* 347-356.

Hundloe, T. (2002) *Valuing fisheries: an economic framework.* University of Queensland Press, St Lucia, Queensland, Australia.

Kaufmann, B., Geen, G., and Sen, S. (1999) *Fish futures: individual transferable quotas in fisheries.* Fisheries Research and Development Corporation and Fisheries Economics, Research and Management Ltd., Kiama, NSW.

King, M., (2007) *Fisheries biology, assessment and management.* Fishing News Books a Division of Blackwell Science Ltd., Oxford.

Korn, H., Schliep, R., and Stadler, J. (2003). *Report of the international workshop on the further development of the ecosystem approach.* BfN-Skrpten 78. Bundesmat fur Naturschutz (BfN), Federal Agency for Nature Conservation, Germany.

Lackey, R. (1998) Fisheries management: integrating societal preference, decision analysis, and ecological risk assessment. *Environmental Science and Policy* 1:329-335.

Leadbitter, D., and Ward, T. (2007) An evaluation of systems for integrated assessment of capture fisheries. *Marine Policy* 31:458-469.

Link, J.,Brodziak, J., Edwards, S., Overholtz, W., Mountain, D., Jossi, J., Smith, T., and Fogarty, M. (2002) Marine ecosystem assessment in a fisheries management context. *Canadian Journal of Fisheries and Aquatic Science* 59:1429-1440.

Lobe, K., and Berkes, F. (2004) The *padu* system of community-based fisheries management: change and local institutional innovation in south India. *Marine Policy* 28:271-281.

Mace, P. (2001) A new role for MSY in single-species and ecosystem approaches to fisheries stock assessment and management *Fish and Fisheries* 2:2-32.

Marasco, R., Goodman, D., Grimes, C., Lawson, P., Punt, A., and Quinn III, T. (2007) Ecosystem-based fisheries management: some practical suggestions. *Canadian Journal of Fisheries and Aquatic Sciences* 64:928-939.

Marine Stewardship Council (2002) *MSC principles and criteria for sustainable fishing*, viewed 4 February 2010 <www.msc.org/documents/msc-standards/MSC_environmental_standards_for_sustainable _fishing.pdf/view>

May, B., Leadbitter, D., Sutton, M., and Weber, M. (2003) The Marine Stewardship Council (MSC) background, rationale and challenges in *Eco-labelling in fisheries: what is it all about?* Eds. Phillips, B., Ward, T., and Chaffee, C. Blackwell Science, Oxford, UK.

Mayer, A. (2008) Strengths and weaknesses of common sustainability indices for multidimensional systems. *Environment International* 34:277-291.

McAllister, M., Starr, P., Restrepo, V., and Kirkwood, G. (1999) Formulating quantitative methods to evaluate fishery-management systems: what fishery processes should be modelled and what trade-offs should be made? *ICES Journal of Marine Science* 56:900-916.

McFadden, K., and Barnes, C. (2009) The implementation of an ecosystem approach to management within a federal government agency. *Marine Policy* 33:156-163.

McGarvey, R. (2003) Demand-side fishery management: integrating two forms of input control. *Marine Policy* 27:207-218.

McPhee, D. (2008) *Fisheries Management in Australia.* The Federation Press, Sydney, Australia.

Morrow, D., and Rondinelli, D. (2002) Adopting corporate Environmental Management Systems: motivations and results of ISO 14001 and EMAS Certification. *European Management Journal* 20(2):159-171.

Murawski, S. (2007) Ten myths concerning ecosystem approaches to marine resource management. *Marine Policy* 31:681-690.

Ostrom, E. (2008) The economic analysis of institutions: institutions and the environment. *Institute of Economic Affairs* 24-31.

Parkes, G. (2000) Precautionary fisheries management: the CCAMLR approach. *Marine Policy* 24:83-91.

Pascoe, S., Bustamante, R., Wilcox, C., and Gibbs, M. (2009) Spatial fisheries management: a framework for multi-objective qualitative assessment. *Oceans and Coastal Management* 52:130-138.

Pauly, D., Watson, R., and Christensen, V. (2003) Ecological geography as a framework for a transition towards responsible fishing in *Responsible fisheries in the marine ecosystem.* Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

Peterman, R. (2004) Possible solutions to some challenges facing fisheries scientists and managers. *ICES Journal of Marine Science* 61:1331-1343.

Ponte, S. (2008) Greener than thou: the political economy of fish ecolabelling and its local manifestations in South Africa. *World Development* 36(1):159-175.

Rice, J. (2008) Can we manage ecosystem in a sustainable way? *Journal of Sea Research* 60:8-20.

Sainsbury, K. (2008) *Best practice reference points for Australian fisheries.* A report to the Australian Fisheries Management Authority and the Department of Environment, Water, Heritage and the Arts. AFMA Report No. R2001/0999. Australian Fisheries Management Authority, Canberra, Australia.

Sainsbury, K. and Sumaila, U. (2003) Incorporating ecosystem objectives into management of sustainable marine fisheries, including best practice reference points and use of marine protected areas in *Responsible fisheries in the marine ecosystem.* Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

Sainsbury, K.J., Punt, A.E. and Smith, A.D.M. (2000) Design of operational management strategies for achieving fishery ecosystem objectives. *ICES Journal of Marine Science* 57, 731-741.

Sanchirico, J., Holland, D., Quigley, K., and Fina, M. (2006) Catch-quota balancing in multispecies individual fishing quotas. *Marine Policy* 30:767-785.

Sanchirico, J., Smith, M., and Lipton, D. (2008) An empirical approach to ecosystem-based fishery management. *Ecological Economics* 64:586-596.

Seafood Services Australia (2005) *Take your pick! the seafood EMS chooser.* 2nd edition. Seafood Services Australia Ltd., QLD, Australia.

Seijo, J. and Caddy, J. (2000) Uncertainty in bio-economic reference points and indicators of marine fisheries. *Marine Freshwater Research* 51:477-483.

Sissenwine, M. and Mace, P. (2003) Governance for Responsible Fisheries: an ecosystem approach in *Responsible fisheries in the marine ecosystem.* Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

Slocombe, D. (1998) Defining goals and criteria for ecosystem based management. *Environmental Management* 22(4): 483-493.

Smith, A., Sainsbury, L., and Stevens, J. (1999) Implementing effective fisheries-management systems- management strategy evaluation and the Australian partnership approach. *ICES Journal of Science* 56:967-979.

Smith, T., Gibbs, M., and Smith, D. (2009) Fishing for more effective incentives. *Science* 323:337-338.

Smith, A., Sachse, M., Smith, D., Prince J., Knuckey, I., Baelde, P., Walker T. and Talman S. (2004) *Alternative management strategies for the Southern and Eastern Scalefish and Shark Fishery – qualitative assessment report.* Australian Fisheries Management Authority, Canberra, Australia.

Stafford, R. (2008) A computational approach to ecological and economic sustainable harvest management strategies in a multi-species context, with implications for cod recovery plans. *Ecological Informatics* 3:105-110.

Stefansson, G. (2003) Multi-species and ecosystem models in a management context in *Responsible fisheries in the marine ecosystem.* Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

Sumaila, R., Guenette, S., Alder, J., and Chuenpagdee, R. (2000) Addressing ecosystem effects of fishing using marine protected areas. *ICES Journal of Marine Science* 57:752-760.

Sutinen, J. What works well and why: evidence from fishery management experiences in OECD countries. *ICES Journal of Marine Science* 56:1051-1058.

Symes, D. (2007) Fisheries management and institutional reform: a European perspective. *ICES Journal of Marine Science* 64:779-785.

Thomspon, M., Dumont, C., and Gaymer, C. (2008) ISO 14001: towards international quality environmental management standards for marine protected areas. *Ocean and Coastal Management* 51:727-739.

United Nations Conference on the Environment and Development (UNCED (1992) *Rio Declaration.* United Nations Department of Public Information, New York, USA.

United Nations (2002) *Report of the World Summit on Sustainable Development Johannesburg, South Africa 26 August - 4 September 2002.* United Nations, New York.

Ward, T., Tarte, D., Hegerl, E., Short, K. (June 2002) *Policy proposals and operational guidance for Ecosystem-Based Management of marine capture fisheries.* World Wide Fund for Nature (WWF) Australia.

Ward, T., Phillips, B., and Chaffe, C. (2003) Conclusions in *Eco-labelling in fisheries: what is it all about?* Eds. Phillips, B., Ward, T., and Chaffee, C. Blackwell Science, Oxford, UK.

White, R., Fischer, A., Marshall, K., Travis, J., Webb, T., di Falco, S., Redpath, S., and van der Wal, R. (2009) Developing an integrated conceptual framework to understand biodiversity conflicts. *Land Use Policy* 26:242-253.

Chapter 6

Abuodha, P., and Woodroffe C. (2006) *International assessment of the vulnerability of the coastal zone to climate change, including an Australian perspective.* Australian Greenhouse Office, Canberra.

Anderson, J., and Valderrama, D. (2009) Trends in the international trade of seafood products in *International seafood trade: challenges and opportunities.* Eds. Einarsson, H., and Emerson, W. FAO/University of Akureyi Symposium 1-2 February 2007, Akureyri, Iceland. FAO Fisheries and Aquaculture Proceedings No. 13. FAO, Rome.

Aquaculture Committee of the Marine and Coastal Committee (February 2005) *Best practice framework of regulatory arrangement for aquaculture in Australia.* Department of Agriculture, Fisheries and Forestry, Canberra ACT.

Australian and New Zealand Environment and Conservation Council, State of the Environment Reporting Task Force (2000) *Core environmental indicators for reporting on the State of the Environment.* Environment Australia, Canberra.

Australian and New Zealand Environment and Conservation Council Task Force on Marine Protected Areas (1998) *Guidelines for establishing the National Representative System of Marine Protected Areas.* Australian and New Zealand Environment and Conservation Council Task Force on Marine Protected Areas, Environment Australia, Canberra.

Australian and New Zealand Environment and Conservation Council Task Force on Marine Protected Areas (July 1999) *Strategic plan of action for the National Representative System of Marine Protected Areas: a guide for action by Australian Governments.* Environment Australia, Canberra.

Australian Antarctic Division (2006) *Threat abatement plan 2006 for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations.* Australian Antarctic Division, Department of the Environment and Heritage, Kingston, Tasmania.

Australian Conservation Foundation (2005) *Marine legislative review of selected Commonwealth and States conservation, fisheries, petroleum, shipping and tourism.*

Australian Conservation Foundation, Carlton Victoria and the National Environmental Law Association, Canberra, ACT.

Australian Conservation Foundation and the National Environmental Law Association (March 2006) *Out of the Blue: an act for Australia's Oceans.* Australian Conservation Foundation, Carlton Victoria and the National Environmental Law Association, Canberra, ACT.

Australian Fisheries Management Authority (September 2006) New treaty to strengthen the fight against illegal fishing. *AFMA Fishing Future* 4(3):12-13.

Australian Fisheries Management Authority (2009) *Annual report 2008/09.* Australian Fisheries Management Authority, Canberra, ACT.

Australian Government (September 2008) *Caring for our country outcomes 2008-2013.* Australian Government Natural Resource Management, Canberra, ACT.

Australian Government Attorney-Generals Department (1980) *Offshore Constitutional Settlement: a milestone in co-operative federalism.* Australian Government Publishing Services, Canberra.

Australian Government Attorney-Generals Department (3 September 2009) *The Offshore Constitutional Settlement,* viewed 19 February 2010 <http://www.ag.gov.au/www/agd/agd.nsf/Page/InternationalLaw_TheOffshoreConstitutionalSettlement>

Australian Government (15 February 2010) *PIMC-NRMMC,* viewed 19 February 2010 <http://www.mincos.gov.au>

Australian Institute of Marine Science (November 2008) *The AIMS index of marine industry.* Australian Institute of Marine Science, Townsville, Australia.

Australian Marine Industries and Sciences Council (1997) *Marine Industry Development Strategy.* Department of Industry, Science and Tourism, Canberra.

Australian National University (2009) *Implications of climate change for Australia's World Heritage properties: a preliminary assessment.* A report to the Department of Climate Change and the Department of the Environment Water, Heritage and the Arts by the Fenner School of Environment and Society. Department of the Environment Water, Heritage and the Arts, Canberra, ACT.

Australian State of the Environment Committee (2000) Coasts and oceans in *Australia State of the Environment 2001*, an independent report to the Commonwealth Minister for the Environment and Heritage. Commonwealth Scientific and Industrial Research Organisation, Collingwood, Victoria.

Australian State of the Environment Committee (2001) *Australia State of the Environment 2001*, an independent report to the Commonwealth Minister for the Environment and Heritage Commonwealth Scientific and Industrial Research Organisation, Collingwood, Victoria.

Baelde, P. (2005) Interactions between the implementation of marine protected areas and right-based fisheries management in Australia. *Fisheries Management and Ecology* 12:9-18.

Barratt, D., Garvey, J., and Chesson, J. (2001) *Marine disturbance in parts of the Australian Exclusive Economic Zone,* Australia State of the Environment second Technical Paper Series (Coasts and Oceans) Series 2. Bureau of Resource Sciences, Canberra.

Barry, C. (2006) An appraisal of the Department of Environment and Heritage's Strategic Assessment process for Australian Fisheries. *Waves* 12(1): 1-2.

Beeton, R., Buckley, K., Jones, G., Morgan, D., Reichelt, R., E, Trewin, D. (2006) *Australia State of the Environment 2006* an independent report to the Australian Government Minister for the Environment and Heritage. Department of the Environment and Heritage, Canberra, ACT.

Bernal, P., Cincin-Sain, B. and Barbiere, J. Co-Chairs (2001) *Toward the 2002 World Summit on Sustainable Development Johannesburg: ensuring the sustainable development of oceans and coasts a call to action Co-chairs Summary.* Intergovernmental Oceanographic Commission, UNESCO, Paris and Centre for the Study of Marine Policy University of Delaware, USA.

Biodiversity and Climate Change Expert Advisory Group (2009) *Australia's biodiversity and climate change: a strategic assessment of the vulnerability of Australia's biodiversity to climate change.* Summary for policy makers 2009, summary of a report to the Natural Resource Management Ministerial Council. Department of Climate Change Canberra, ACT.

Bowen, B., Ward, T., Butler, A., Cosser, P., Holmes, N., Staples, D., Zann, L., and Haines, A. (1996) Estuaries and the Sea in *Australia State of the Environment Report 1996.* An independent report presented to the Commonwealth Minister for the Environment State of the Environment Advisory Council. Commonwealth Scientific and Industrial Research Organisation, Collingwood, Australia.

Buckee, J. (September 2004) *Assessment and reporting of the ecologically sustainable development of Australian aquaculture: an industry perspective Volume 1.* Department of Agriculture, Fisheries and Forestry, Canberra, ACT.

Bureau of Rural Sciences (2005) *Socio-economic impact assessment toolkit: a guide to assessing the socio-economic impacts of Marine Protected Areas in Australia.* Prepared for the Australian Government Department of the Environment and Heritage by Bureau of Rural Sciences, with Bureau of Transport and Regional Economics, and Australian Bureau of Agricultural and Resource Economics. Bureau of Rural Sciences, Canberra, ACT.

Campbell, A. (April 2007) *Climate change and Australian fisheries knowledge imperatives and research opportunities.* A report for the Fisheries Research and Development Corporation. Fisheries Research and Development Corporation, Canberra, ACT.

C& R Consulting (19 June 2009) *Impacts of plastic debris on Australian marine wildlife.* Department of the Environment and Heritage, Canberra, ACT.

Chesson, J. and Clayton, H. (1998) *Framework for assessing performance against the ESD objectives of Commonwealth fisheries management* Bureau of Rural Sciences, Canberra, ACT.

Chesson, J., Whitworth, B., (March 2004) *A stocktake of environmental, socio-economic and governance performance assessment systems in use by Australian Governments.* Bureau of Rural Sciences, Canberra, ACT.

Commonwealth of Australia (1992) *National Strategy for Ecologically Sustainable Development.* Prepared by the Ecologically Sustainable Development Steering Committee. Endorsed by the Council of Australian Governments December 1992. Australian Government Publishing Services, Canberra, ACT.

Commonwealth Government (1999a reprint) *Australia's Oceans Policy 1: caring, understanding and using wisely.* Environment Australia, Canberra, ACT.

Commonwealth Government (1999b reprint) *Australia's Oceans Policy 2: specific sectoral measures* Environment Australia, Canberra, ACT.

Commonwealth of Australia (June 2006) *A guide to the Integrated Marine and Coastal Regionalisation of Australia IMCRA version 4.0.* Department of the Environment and Heritage, Canberra, ACT.

Council of Australian Governments (5 November 2008) *About COAG,* viewed 8 February 2010 <http://www.coag.gov.au/about_coag/index.cfm>

Department of Agriculture, Fisheries and Forestry (July 2005) *Australian national plan of action to prevent, deter and eliminate Illegal, Unreported and Unregulated fishing.* Department of Agriculture, Fisheries and Forestry, Canberra, ACT.

Department of Agriculture, Fisheries and Forestry (6 September 2006a) *Indonesia – Australia fisheries cooperation,* viewed 8 February 2010 <www.daff.gov.au/fisheries/international/regional/indonesia>

Department of Agriculture, Fisheries and Forestry (6 September 2006b) *New Zealand – Australia fisheries cooperation,* viewed 8 February 2010 <www.daff.gov.au/fisheries/international/regional/newzealand>

Department of Agriculture, Fisheries and Forestry (29 January 2008) *National aquaculture policy statement,* viewed 18 February 2010 <http://www.daff.gov.au/fisheries/aquaculture/publications/policy-statement>

Department of Agriculture, Fisheries and Forestry (1 October 2008) *Papua New Guinea – Australia fisheries cooperation,* viewed 8 February 2010 <www.daff.gov.au/fisheries/international/regional/png>

Department of Agriculture, Fisheries and Forestry (5 November 2008) *International fisheries (Regional Fisheries Management Organisation (RFMOs)/conventions,* viewed 11 February 2010 <http://www.daff.gov.au/fisheries/international>

Department of Agriculture, Fisheries and Forestry (20 February 2009) *Recreational Fishing Industry Development Strategy (RFIDS),* viewed 18 February 2010 <http://www.daff.gov.au/fisheries/recreational/rfids>

Department of Agriculture, Fisheries and Forestry (14 August 2009) *Fisheries home,* viewed 9 February 2010 <http://www.daff.gov.au/fisheries>

Department of Climate Change (13 April 2007) *National climate change adaptation framework.* Department of Climate Change, Canberra, ACT.

Department of Climate Change (2009a) *Australian climate change science: a national framework.* Department of Climate Change, Canberra ACT.

Department of Climate Change (2009b) *Climate change risks to Australia's coast: a first pass national assessment.* Department of Climate Change, Canberra ACT.

Department of the Environment and Heritage (2006) *Marine bioregional planning: a new focus for Australia's marine planning.* Department of the Environment and Heritage, Canberra, ACT.

Department of the Environment and Water Resources (18 December 2007) *Goals and principles for the establishment of the National representative systems of MPAs in Commonwealth waters,* viewed 16 February 2010 <www.environment.gov.au/coasts/mbp/publications/general/pubs/goals-nrsmpa.html>

Department of the Environment, Sport and Territories (1996) *National Strategy for the Conservation of Australia's Biological Diversit*y, viewed 15 February 2010 <http://www.environment.gov.au/biodiversity/publications/strategy/index.html>

Department of the Environment Water, Heritage and the Arts (15 April 2005) *Intergovernmental Agreement on the National System for the Prevention and Management of Marine Pest Incursions,* viewed 16 February 2010 <www.environment.gov.au/coasts/imps/publications/intergovernmental-agreement.html>

Department of the Environment Water, Heritage and the Arts (1 May 1992) *Intergovernmental Agreement on the Environment 1 May 1992,* viewed 8 February 2010 <http://www.environment.gov.au/esd/national/igae/index.html>

Department of the Environment Water, Heritage and the Arts (14 March 2008) *Living on saltwater,* viewed 18 February 2010 <http://www.environment.gov.au/indigenous/programs/sea.html>

Department of the Environment, Water, Heritage and the Arts (10 October 2008) *Sea country plans,* viewed 18 February 2010 <http://www.environment.gov.au/indigenous/programs/scp.html>

Department of the Environment, Water, Heritage and the Arts (2009) *Matters of national environmental significance: significant impact guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999.* Department of the Environment and Heritage, Canberra, ACT.

Department of the Environment, Water, Heritage and the Arts (21 January 2009) *Threatened species under the Environment Protection and Biodiversity Conservation Act 1999,* viewed 17 February 2010 <http://www.environment.gov.au/biodiversity/threatened/species.html>

Department of the Environment, Water, Heritage and the Arts (6 April 2009) *Threatened ecological communities under the Environment Protection and Biodiversity Conservation Act 1999,* viewed 17 February 2010 <http://www.environment.gov.au/biodiversity/threatened/communities.html>

Department of the Environment, Water, Heritage and the Arts (8 October 2009) *Marine bioregional planning,* viewed 15 February 2010 <http://www.environment.gov.au/coasts/mbp/index.html>

Department of the Environment, Water, Heritage and the Arts (3 November 2009) *Guidelines for the ecologically sustainable management of fisheries,* viewed 8 February 2010 <http://www.environment.gov.au/coasts/fisheries/publications/guidelines.html>

Department of the Environment, Water, Heritage and the Arts (18 November 2009) *Threat abatement plans,* viewed 17 February 2010 <http://www.environment.gov.au/biodiversity/threatened/tap.html>

Department of the Environment, Water, Heritage and the Arts (23 November 2009) *Recovery plans,* viewed 17 February 2010 <http://www.environment.gov.au/biodiversity/threatened/recovery.html>

Department of the Environment, Water, Heritage and the Arts (25 November 2009) *What is protected under the EPBC Act?* viewed 8 February 2010 <http://www.environment.gov.au/epbc/protect/index.html>

Department of the Environment, Water, Heritage and the Arts (3 December 2009) *Key threatening processes under the Environment Protection and Biodiversity Conservation Act 1999,* viewed 17 February 2010 <http://www.environment.gov.au/biodiversity/threatened/ktp.html>

Department of the Environment, Water, Heritage and the Arts (10 December 2009) *Fisheries and the environment,* viewed 8 February 2010 <http://www.environment.gov.au/coasts/fisheries/index.html>

Department of the Environment, Water, Heritage and the Arts (20 January 2010) *Migratory species in Australia,* viewed 17 February 2010 <http://www.environment.gov.au/biodiversity/migratory/index.html>

Department of the Environment, Water, Heritage and the Arts (29 January 2010) *EPBC Act fisheries assessment,* viewed 17 February 2010 <http://www.environment.gov.au/epbc/assessments/fisheries.html>

Department of Environment, Water, Heritage and the Arts (February 2010) *National Pollutant Inventory guide Version 5.1,* Department Environment, Water, Heritage and the Arts, Canberra, ACT.

Department of the Environment, Water, Heritage and the Arts (5 February 2010) *Department of the Environment, Water, Heritage and the Arts,* viewed 16 February 2010 <http://www.environment.gov.au/index.html>

Department of the Environment, Water, Heritage and the Arts (15 February 2010) *Wildlife trade and conservation,* viewed 17 February 2010 <http://www.environment.gov.au/biodiversity/trade-use/index.html>

Dunlop, M. and Brown, P. (March 2008) *Implications of climate change for Australia's national reserve system: a preliminary assessment.* Report to the Department of Climate Change, February 2008. Department of Climate Change, Canberra, ACT.

Fisheries Research and Development Corporation ESD Subprogram (2010) *Overview of the ESD Reporting and Assessment (ESDRA) Subprogram,* viewed 8 February 2010 <http://www.fisheries-esd.com/c/subprogram/subprogram0200.cfm>

Foster, E., and Haward, M. (2003) Integrated management councils: a conceptual model for ocean policy conflict management in Australia. *Ocean and Coastal Management* 46:547-563.

Great Barrier Reef Marine Park Authority (2010) *About us,* viewed 9 February 2010 <http://www.gbrmpa.gov.au/corp_site/about_us>

Harding, R. (1998). *Environmental decision-making: the roles of scientists, engineers and the public.* The Federation Press, Sydney.

Haward, M. (1989) The Australian Offshore Constitutional Settlement. *Marine Policy* 13:334-348.

Haward, M and Vince, J (2009) Australian ocean governance: initiatives and challenges. *Coastal Management* 37(1): 1-16.

Hemer, M., McInnes, K., Church, J., O'Grady, J., and Hunter, J. (9 September 2008) *Variability and trends in the Australian wave climate and consequent coastal vulnerability.* Final Report for the Department of Climate Change. Commonwealth Scientific and Industrial Research Organisation, Hobart, TAS.

Hilbert, D., Hughes, L., Johnson, J., Lough, J., Low, T., Pearson, R., Sutherst, R., and Whittaker, S. (March 2007) *Biodiversity conservation research in a changing climate.* Workshop report: research needs and information gaps for the implementation of the key objectives of the National Biodiversity and Climate Change Action Plan. Natural Resource Management Policy Branch Department of the Environment and Water Resources, Canberra, ACT.

Hobday, A., Okey, T., Poloczanska, E., Kunz, T., and Richardson, A. Eds. (September 2006a) *Impacts of climate change on Australian marine life: Part A Executive Summary.* Report to the Australian Greenhouse Office Department of the Environment and Heritage. Australian Greenhouse Office, Canberra, ACT.

Hobday, A., Okey, T., Poloczanska, E., Kunz, T., and Richardson, A. Eds. (September 2006b) *Impacts of climate change on Australian marine life: Part B Technical Report.* Report to the Australian Greenhouse Office, Department of the Environment and Heritage. Australian Greenhouse Office, Canberra, ACT.

Hobday, A., Okey, T., Poloczanska, E., Kunz, T., and Richardson, A. Eds. (September 2006c) *Impacts of climate change on Australian marine life: Part C Literature Review.* Report to the Australian Greenhouse Office, Department of the Environment and Heritage. Australian Greenhouse Office, Canberra, ACT.

Hobady, A., Poloczanska, E., Matear, R. Eds. (2008) *Implications of climate change for Australian fisheries and aquaculture: a preliminary assessment.* Report to the Department of Climate Change. Department of Climate Change, Canberra, ACT.

Hohnen, L., Wood, R., Newton, P., Jahan, N., and Vieria, S. (2008) *Fishery economic status report 2007.* Australian Bureau of Agriculture and Resource Economics Report 08.10 prepared for the Fisheries Resources Research Fund. Australian Bureau of Agriculture and Resource Economics, Canberra, ACT.

Hyder Consulting Pty Ltd. (March 2008) *The impacts and management implications of climate change for the Australian Government's protected areas.* A report to the Department of the Environment Water, Heritage and the Arts and Department of Climate Change. Department of Climate Change, Canberra, ACT.

Johnson, J., and Marshall, P. Eds. (2007) C*limate change and the Great Barrier Reef: a vulnerability assessment.* Great Barrier Reef Marine Park Authority and Australian Greenhouse Office, Canberra, ACT.

Jentoft, S. (2007) Limits of governability: institutional implications for fisheries and coastal governance. *Marine Policy* 31:360-370.

Lee, C., and Nel, S. (March 2001) *A national aquaculture development strategy for Indigenous communities in Australia.* Department of Agriculture, Fisheries and Forestry Canberra ACT.

Marine Biodiversity Decline Working Group (April 2008) *A national approach to addressing marine biodiversity decline.* Report to the Natural Resource Management Ministerial Council Department of the Environment, Water, Heritage and the Arts, viewed 20 February 2010 <http://www.environment.gov.au/coasts/publications/marine-diversity-decline/index.html>

Marine and Coastal Community Network (MCCN) MCCN Survey on the EPBC Act fisheries strategic assessments. *Waves* 12(1):7-10.

McPhee, D. (2008) *Fisheries Management in Australia.* The Federation Press, Sydney, Australia.

Miller, K. (2007) Climate variability and tropical tuna: management challenges for highly migratory fish stocks. *Marine Policy* 31(1):56-70.

Ministerial Council on Forestry, Fisheries and Aquaculture (August 1999) *National Policy on Fisheries Bycatch.* Department of Agriculture, Fisheries and Forestry, Canberra ACT.

National Aquaculture Council (July 2007) *Sustainable aquaculture: development strategy.* Department of Agriculture, Fisheries and Forestry Canberra ACT.

National Biodiversity Strategy Review Task Group (March 2009) *Australia's biodiversity strategy 2010-2020 consultation draft.* Department of Environment, Water, Heritage and the Arts, Canberra, ACT.

National Recreational fisheries Working Group (December 1994) *The National recreational fishing policy*, viewed 20 February <http://www.daff.gov.au/fisheries/recreational/policy>

National Marine Protected Areas Working Group (April 2008) *Progress in implementing the National Representative system of Marine Protected Areas (NRSMPA).* Report to the Natural Resource Management Ministerial Council. Department of the Environment, Water, Heritage and the Arts, viewed 20 February <http://www.environment.gov.au/coasts/mpa/publications/nrsmpa-report.html>

National Working Party on Acid Sulphate Soils (January 2000) *National strategy for the management of coastal acid sulphate soils initiative.* NSW Agricultural Institute, Wollongbar, NSW.

Natural Resource Management Ministerial Council (2004) *National biodiversity and climate change action plan 2004-200*7. Department of the Environment and Heritage, Canberra, ACT.

Natural Resource Management Ministerial Council (October 2006) *Australia's national programme of action for the protection of the marine environment from land-based activities.* Department of the Environment and Heritage, Canberra, ACT.

Natural Resource Management Ministerial Council (2006) *National cooperative approach to integrated coastal zone management framework and implementation plan.* Department of the Environment and Heritage, Canberra, ACT.

Norwood, C. (Autumn 2008) Apprehension, prosecution and education. *AFMA Fishing Future* 6(1):12-13.

Pittock, B. Ed. (2003) *Climate change: an Australian guide to the science and potential impacts* Australian Greenhouse Office, Canberra, ACT.

Productivity Commission (1999) *Implementation of Ecologically Sustainable Development by Commonwealth Departments and Agencies Report No. 5* AusInfo, Canberra, ACT.

Ridgeway., L. (2007) Chairs summary report in *Globalisation and fisheries: proceedings of an OECD-FAO Workshop.* Workshop on the challenges and opportunities of fisheries globalisation Paris,16-17 April 2007. Organisation for Economic Co-operation and Development, Paris, France.

Rothwell, D., and Haward, M. (1996) Federal and international perspectives on Australia's maritime claims. *Marine Policy* 20(1):29-46.

Sainsbury, K, Smith, A. Webb, H. (1998) C*urrent use and recommendations for future development of sustainability indicators to measure performance of Australian fisheries against ESD objectives.* FRDC project No. 98/168. Fisheries Research and Development Corporation and Commonwealth Scientific and Industrial Research Organisation, Hobart, Tasmania.

Schmidt, C. (2004) Globalisation, industry structure, market power and impact of fish trade opportunities and challenges fir developed OECD countries in *Report of the expert consultation on international fish trade Rio de Janeiro, Brazil 3-5 December 2003.* FAO Fisheries Report No. 744. FAO, Rome.

Shark Advisory Group and Lack, M. (May 2004) *National Plan of Action for the conservation and management of sharks (Shark-plan).* Department of Agriculture, Fisheries and Forestry, Canberra, ACT.

Smith, D. and Hodge, R. Eds. (June 2001) *ESD and Fisheries: What, Why, How and When.* A Stakeholders Workshop Proceedings 23-24 March 2000,Geelong. Victoria. Seafood Industry Victoria Inc., South Yarra, Victora.

Smith, D., Smith, T., Dichmont, C., Davies, C., Bodsworth, A., Gooday, P., Galeano, D., McLoughlin, K., Knuckey, I., Haddon, M., and Jackson, G. (September 2007) *Commonwealth fisheries harvest strategy: policy and guidelines.* Department of Agriculture, Fisheries and Forestry Canberra, ACT.

Smyth, C., Prideaux, M., Davey, K., and Grady, M. (March 2003) *Oceans Eleven: the implementation of Australia's Oceans Policy and ecosystem-based regional marine planning.* Australian Conservation Foundation, Carlton, Victoria.

State of the Environment Advisory Council (1996) *Australia State of the Environment 1996.* An independent report presented to the Commonwealth Minister for the

Environment. Commonwealth Scientific and Industrial Research Organisation, Collingwood, Australia.

TFG International (25 October 2002) *Review of the implementation of oceans policy.* Department of the Environment, Water and Heritage, and the Arts, Canberra, ACT.

The Allen Consulting Group (June 2004) *The economic contribution of Australia's marine industries: 1995-96 to 2002-03.* Report to the National Oceans Office. Department of the Environment and Heritage, Canberra, ACT.

The Allen Consulting Group (March 2005) *Climate change risk and vulnerability: promoting an efficient adaptation response in Australia.* Report to the Australian Greenhouse Office. Australian Greenhouse Office, Canberra, ACT.

The inter-governmental National Seal Strategy Group (2007) *National strategy to address interactions between humans and seals: fisheries, aquaculture and tourism.* Department of Agriculture, Fisheries and Forestry, Canberra, ACT.

The Marine Science and Technology Plan Working Group (June 1999) *Australia's marine science and technology plan.* Department of Industry, Science and Resources, Canberra, ACT.

The National System for the Prevention and Management of Marine Pest Incursions (4 May 2009) *How does the National system work?* viewed 16 February 2010 <www.marinepests.gov.au/national_system/how-it-works>

The Scientific Review Panel for the National Representative System of Marine Protected Areas (20 February 2006) *Guidance on achieving comprehensiveness, adequacy, and representativeness in the Commonwealth waters component of the National Representative Systems of Marine Protected Areas.* Department of the Environment, Water, Heritage and the Arts, viewed 16 February 2010 <www.environment/gov.au/costs/mbp/publications/general/guidance-nrsmpa.html>

Tsamenyi, M., Rose, G., and Castle, A. (September 2003) International conservation law and its implementation in Australia in *Conserving marine environments: out of sight out of mind.* Eds. Hutching, P., and Lunney, D. Royal Zoological Society of New South Wales, Mosman NSW, Australia.

United Nations Conference on the Environment and Development (UNCED (1992a) *Rio Declaration.* United Nations Department of Public Information, New York, USA

United Nations Conference on the Environment and Development (UNCED) (1992b) *Agenda 21.* United Nations Department of Public Information, New York, USA

United Nations (2002) *Report of the World Summit on Sustainable Development Johannesburg, South Africa 26 August -4 September 2002.* United Nations, New York.

Valdimarsson, G. (2009) Fish in the global food chain: challenges and opportunities in *International seafood trade: challenges and opportunities.* Eds. Einarsson, H., and Emerson, W. FAO/University of Akureyi Symposium 1-2 February 2007, Akureyri, Iceland. FAO Fisheries and Aquaculture Proceedings No. 13. FAO, Rome.

Vince, J. (2007) Policy responses to IUU fishing in Northern Australian waters. *Ocean and Coastal Management* 50:683-698.

Voice, M., Harvey, N., and Walsh, K. Eds. (2006) V*ulnerability to climate change of Australia's coastal zone: analysis of gaps in methods, data and system thresholds*. Report to the Australian Greenhouse Office, Department of the Environment and Heritage. Australian Greenhouse Office, Canberra, ACT.

Ward, T., and Butler, A. (2006) Coasts and oceans, theme commentary prepared for the Australian State of the Environment Committee in *Australian State of the Environment 2006.* Department of Environment and Heritage, Canberra, ACT.

Webb, H., and Smith, T. (2008) *Review of the scope, assessment methods and management responses for fisheries ESD and EBFM in Australia.* FRDC Report 2004/101. Fisheries Research and Development Corporation and Commonwealth Scientific and Industrial Research Organisation, Hobart, Tasmania.

Westcott, G. (2006) The long and winding road: the development of a comprehensive, adequate and representative system of highly protected marine protected areas in Victoria, Australia. *Ocean and Coastal Management* 49:905-922.

Whitworth, B., Chesson, J., Fletcher, W., Sainsbury, K., Fisher, M., Hundloe, T., and Smith, A.(2002) *National ESD reporting framework for Australian fisheries: Technical*

Support Document – Ecological Components of the 2000/2001 Case Studies. FRDC Project 2000/145. Fisheries Research and Development Corporation, Canberra, ACT.

Williams, M. (2007) *Enmeshed Australia and southeast Asia's fisheries.* Lowy Institute Paper No. 20. Lowy Institute for International Policy, Double Bay, New South Wales, Australia.

World Commission on Environment and Development (1987) *Our common future.* Oxford University Press, Oxford.

World Summit on Sustainable Development (2002) *The Johannesburg Plan of Implementation of the World Summit on Sustainable Development.* UN Department of Social and Economic Affairs (11 August 2005) Division for Sustainable Development, viewed 11 March 2010 <http://www.un.org/esa/sustdev/documents/WSSD_POI_PD/English/POIToc.htm>

Zagonari, F. (2008) Integrated coastal management: top-down vs. community-based approaches. *Journal of environmental Management* 88:796-804.

Zann, L. (1995) *Our sea our future major findings of State of the marine environment report for Australia.* Department of the Environment, Sport and Territories, Canberra, ACT.

Acts, conventions and agreements

Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES) 1973

Convention on Biological Diversity 1992

Environment Protection (Sea Dumping) Act 1981

Environment Protection and Biodiversity Conservation Act 1999

Fisheries Management Act 1991

Fisheries (Management) Regulations 1992

Fisheries Administration Act 1991

Fisheries (Administration) Regulations 1992

Great Barrier Reef Marine Park Act 1975

The Convention on Wetlands of International Importance especially as Water Fowl Habitat (Ramsar) 1971

Torres Strait Fisheries Act 1984

Torres Strait (Fisheries) Regulations 1985

Wildlife Protection Act 1982

Chapter 7

Australian Fisheries Management Authority (14 August 2006) *Partnerships,* viewed 23 February 2010 <http://www.afma.gov.au/management/partnerships/default.htm>

Australian Fisheries Management Authority (23 November 2005) *AFMA Update,* viewed 24 February 2010 <http://www.afma.gov.au/information/publications/newsletters/afma_update/docs/update_0224/update_0224.htm>

Australian Fisheries Management Authority (25 February 2009) *AFMA Update,* viewed 22 February 2010 <http://www.afma.gov.au/information/publications/newsletters/afma_update/docs/update_0604/update_0604.htm>

Beddington, J., Agnew, D., and Clark, C. (2007) Current problems in the management of marine fisheries. *Science* 316:1713-1716.

Beeton, R., Buckley, K., Jones, G., Morgan, D., Reichelt, R., E, and Trewin, D. (2006) Coasts and Oceans in *Australia State of the Environment 2006.* Independent report to the Australian Government Minister for the Environment and Heritage, Department of the Environment and Heritage, Canberra, ACT.

Bishop, C. (2008) Fisheries find their way through a sea of green. *FISH* 16(3):18-19.

Bradshaw, M. (2004) A combination of state and market through ITQs in the Tasmanian commercial rock lobster fishery: the tail wagging the dog? *Fisheries Research* 67:99-109.

Brooks, K. (20 January 2009) *Social Sciences Research Coordination Program (SSRCP): draft terms of reference.* Fisheries Research and Development Corporation, Canberra, ACT.

Bureau of Rural Sciences (28 March 2007) *Fishing technology,* viewed 23 February 2010 <http://www.daff.gov.au/brs/fisheries-marine/info/technology>

Butterworth and Punt (2003) The role of harvest control laws, risk and uncertainty and the precautionary approach to ecosystem-based management in *Responsible fisheries in* *the marine ecosystem.* Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

Cardin, S., and Pastoors, M. (2008) Precautionary harvest policies and the uncertainty paradox. *Fisheries Research* 94:367-372.

Charles, A. (2001) *Sustainable fishery systems.* Blackwell Science, Oxford.

Chesson, J. and Clayton, H. (1998) *Framework for assessing performance against the ESD objectives of Commonwealth fisheries management* Bureau of Rural Sciences, Canberra, ACT.

Department of Agriculture, Fisheries and Forestry (June 2003) *Looking to the future a review of Commonwealth fisheries policy.* Department of Agriculture, Fisheries and Forestry, Barton, ACT.

Department of Agriculture, Fisheries and Forestry (26 October 2009) *Securing our fishing future*, viewed 24 February 2010 <http://www.daff.gov.au/fisheries/domestic/fishingfuture>

Department of Environment and Heritage (2004) *Marine Protected Areas and displaced fishing: a policy statement.* Department of Environment and Heritage, Canberra, ACT.

Department of the Environment and Heritage (2006) *Progress in accessing environmental data and information.* Paper prepared for the 2006 Australian State of the Environment

Committee, Department of the Environment and Heritage, Canberra, ACT.

Department of the Environment, Water, Heritage and the Arts (9 December 2009) *South-east Commonwealth Marine Reserves Network,* viewed 24 February 2010 <http://www.environment.gov.au/coasts/mpa/southeast/index.html>

Department of Foreign Affairs and Trade (August 2008) *About Australia the Australian seafood industry,* viewed 21 February 2010 <http://www.dfat.gov.au/facts/seafoodindustry.html>

Dichmont, C., Deng, A., Punt, A., Ellis, N., Venables, W., Kompas, T., Ye, Y., Zhou, S., and Bishop, J. (2008) Beyond biological performance measures in management strategy evaluation: bringing in economics and the effects of trawling on the benthos. *Fisheries Research* 94:238-250.

Dowling, N., Smith, D., Knuckey, I., Smith, A., Domaschenz, P., Patterson, H., and Whitelaw, W. (2008) Developing harvest strategies for low-value and data-poor fisheries: case studies from three Australian fisheries. *Fisheries Research* 94:380-390.

Fisheries Economics, Research and Management Pty Ltd. (January 2008) *Co-management for Commonwealth fisheries.* Report R05/0783. Australian Fisheries Management Authority, Canberra, ACT.

Fisheries Research and Development Corporation National Working Group (2008) *Co-management: managing Australia's fisheries through partnership and delegation.* Report of the FRDCs national working group for the fisheries co-management initiative Project No. 2006/068. Fisheries Research and Development Corporation, Deakin, ACT.

Fletcher, W. (2005a) The application of qualitative risk assessment methodology to prioritize issues for fisheries management. *ICES Journal of Marine Science* 62:1576-1587.

Fletcher, W. (2005b) *ESD Reporting and Assessment Subprogam: strategic planning, project management and adoption.* Final Report FRDC Project No. 2001/082. Fisheries Research and Development Corporation, Canberra, ACT.

Fletcher, W. (2006) Frameworks for managing marine resources using ecosystem approaches: how do they fit together and are they useful? *Bulletin of Marine Science* 78(3):691-704.

Fletcher, W. (2009). *ESD Reporting and Assessment Subprogram: Strategic Planning, project management and adoption – stage 2.* Final Report FRDC Project No. 2004/006 Fisheries Research Report No. 190. Department of Fisheries, Perth, Western Australia.

Fletcher, W., Chesson, J., Fisher M., Sainsbury, K., Hundloe, T., Smith, A., and Whitworth, B. (2002) *National ESD Reporting Framework for Australian Fisheries:*

The 'How To' *Guide for Wild Capture Fisheries*. FRDC Project 2000/145. Fisheries Research and Development Corporation, Canberra, ACT.

Fletcher, W., Chesson, J., Fisher M., Sainsbury, K., Hundloe, T., Smith, A., and Whitworth, B. (2003) *National Application of Sustainability indicators for Australian fisheries*. FRDC Project 2000/145. Fisheries Research and Development Corporation, Canberra, ACT.

Fletcher, W., Chesson, J., Fisher M., Sainsbury, K., Hundloe, T (2004) *National ESD reporting framework: the 'How To' guide for Aquaculture.* FRDC Project 2000/145.1. Fisheries Research and Development Corporation, Canberra, ACT.

Fletcher, W., Chesson, J., Sainsbury, K., Hundloe, T., and Fisher, M. (2005) A flexible and practical framework for reporting on ecologically sustainable development for wild capture fisheries. *Fisheries Research* 71:175-183.

Food and Agriculture Organization (FAO) of the United Nations (2009a) *Information and knowledge sharin*g. FAO Technical Guidelines for Responsible Fisheries No.12. FAO, Rome.

Food and Agriculture Organization (FAO) of the United Nations (2009b) *Report of the workshop on toolbox for applying the ecosystem approach to fisheries Rome 26-29 February 2008.* FAO Fisheries and Aquaculture Report No. 884. FAO, Rome.

Ford. W. (2001) Restructuring the Tasmanian rock lobster fishery – the effect of two years of management under individual transferable quotas. *Marine and Freshwater Research* 52:1641-1648.

Fulton, E., Smith, A. and Punt, A. (2005) Which ecological indicators can robustly detect effects of fishing? *ICES Journal of Marine Science* 62:540-551.

Fulton, E., Link, J., Kaplan, I., Johnson, P., Savina-Rolland, M., Ainsworth, C., Horne, P., Gorton, R., Gamble, R., Smith, T., Smith D., (2010) in press. Lessons in modelling and management of marine ecosystems: the Atlantis experience. *Fish and Fisheries*.

Grafton, R., Kompas, T., McLoughlin, R., and Rayns, N. (2007) Benchmarking for fisheries governance. *Marine Policy* 31:470-479.

Grafton, R., Hilborn, R., Ridgeway, L., Squires, D., Williams, M., Garcia, S., Groves, T., Joseph, J., Kelleher, K., Kompas, T., Libecap, G., Lundin, C., Makino, M., Matthiasson, T., McLoughlin, R., Parma, A., Martin, G., Satia, B., Schmidt, C., Tait, M., and Zhang, L. (2008) Positioning fisheries in a changing world. *Marine Policy* 32:630-634.

Grafton, R., and McIlgorm, A. (2009) *Ex ante* evaluation of the costs and benefits of individual transferable quotas: a case-study of seven Australian Commonwealth fisheries. *Marine Policy* 33:714-719.

Haddon, M. (2001) *Modelling and quantitative methods in fisheries.* Chapman and Hall/CRC a CRC Press Company, Boca Raton, Florida.

Hanna, S. and Jentoft, S. (1996) Human use of the natural environment: an overview of social and economic dimensions in *Rights to nature: ecological, economic, and political principles of institutions for the environment.* Eds. Karl-Goran, M., Hanna. S., Folke, C., and Maler, K. Technical editor Jansson, A. Island Press, Washington D.C., California.

Henry, G., and Lyle, J. (2003) *The national recreational and indigenous fishing survey.* FRDC Project No. 99/158. Department of Agriculture, Fisheries and Forestry Canberra, ACT.

Hilborn, R. (2007) Defining success in fisheries and conflicts in objectives. *Marine Policy* 31:153-158.

Hilborn, R., Stokes, K,, Maguire, J., Smith, T., Bostsford, L., Mangel, M.,Orensanz, J., Parma, A., Rice, J., Bell, J., Cochrane, L., Garcia, S., Hall, S., Kirkwood, G., Sainsbury, K., Steffansson, G., and Walters, C. (2004) When can marine reserves improve fisheries management. *Ocean and Coastal Management* 47:197-205.

Hobday, A., Smith, A., Webb, H., Daley, R., Wayte, S., Bulman, C., Dowdney, J., Williams, A., Sporcic, M., Dambacher, J., Fuller, M., and Walker, T. (2007) *Ecological risk assessment for the effects of fishing: methodology.* AFMA Report R04/1072. Australian Fisheries Management Authority, Canberra, ACT.

Hobday, A., Poloczanska, E., and Matear, R. Eds. (2008) *Implication of climate change for Australian fisheries and aquaculture: a preliminary assessment.* Report to the Department of Climate Change. Department of Climate Change, Canberra, ACT.

Hollowed, A,, Bax, N., Beamish, R., Collies, M., Fogarty, M., Livingston, P., Pope, J., and Rice, J. (2000) Are multispecies models an improvement on single-species models for measuring fishing impacts on marine ecosystems. *ICES Journal of Marine Sciences* 57:707-719.

International Organization for Standardization (2009) *Environmental management: the ISO 14000 family of international standards*, viewed 23 February 2010 <http://www.iso.org/iso/theiso14000family_2009.pdf>

King, M., (2007) *Fisheries biology, assessment and management.* Fishing News Books a Division of Blackwell Science Ltd., Oxford.

Larcombe, J., Charalambou, C., Herreria, E., Casey, A., and Hobsbawn, P. (2006) *Marine matters national atlas of Australian Marine fishing and coastal communities.* Bureau of Rural Sciences, Canberra, ACT.

Lehtonen, M, (2004) The environmental–social interface of sustainable development: capabilities, social capital, institutions. *Ecological Economics* 49 (2004) 199-214.

Mapstone, B., Little, L., Punt, A., Davies, C., Smith, A., and Pantus, F., McDonald, D., Williams, A., and Jones, A. (2008) Management strategy evaluation for line fishing in the Great Barrier Reef: balancing conservation and multi-sector fishery objectives. *Fisheries Research* 94:315-329.

McDonald, D., Little, R., Gray., Fulton, E., Sainsbury, K., and Lyne, V. (2008) An agent-based modelling approach to evaluation of multiple-use management strategies for coastal marine ecosystems. *Mathematics and Computers in Simulation* 78:401-411.

McPhee, D. (2008) *Fisheries management in Australia.* The Federation Press, Sydney, Australia.

Millington, P., and Fletcher.W. (2008) *Geelong revisited: from ESD to EBFM – future directions for fisheries management.* Workshop Report FRDC 2008/057, Melbourne

May 2008. Fisheries Occasional Publication No. 52 November 2008. Department of Fisheries, Perth, Western Australia.

Minnegal, M., and Dwyer, P. (2008) Mixed messages: buying back Australia's fishing industry. *Marine Policy* 32:1063-1071.

Momtaz, S., and Gladstone, W. (2008) Ban on commercial fishing in the estuarine waters of New South Wales, Australia: community consultation and social impacts. *Environmental Impact Assessment Revie*w 28:214-225.

Morgan, G.R. (1997) *Individual quota management in fisheries: methodologies for determining catch quotas and initial quota allocation.* FAO Fisheries Technical Paper No. 371. FAO, Rome.

National Fisheries Compliance Committee (NFCC) (15 July 2005) *National compliance strategy 2005-2010.* Australian Fisheries Management Authority Australian Fisheries, Canberra, ACT.

National Fisheries ESD (2010) *Ecologically Sustainable Development Publications*, viewed 23 February 2010 <http://www.fisheries-esd.com/c/pubs/index.cfm>

North West Shelf Joint Environmental Management Study (2007) *North West Shelf Joint Environmental Management Study final report.* Commonwealth Scientific and Industrial Research Organisation and Department of the Environment Western Australia, Hobart Tasmania.

Olsson, P., Folke, C., and Hughes, T. (2008) Navigating the transition to ecosystem-based management of the Great Barrier Reef. *PNAS* 105(28):9489-9494.

O'Neill, M. and Leigh, G. (2007) Fishing power increases continue in Queensland's east coast trawl fishery, Australia. *Fisheries Research* 85:84-92.

O'Neill, M., Courtney, A., Turnbull. C., Good, N., Yeomans, K., Smith, J., and Shootingstar, C. (2003) Comparison of relative fishing power between different sectors of the Queensland trawl fishery, Australia. *Fisheries Research* 65:309-321.

Petrachenko, D. (2007) *Fishery accreditation in Australia.* Seafood Directions 2007 Conference Proceeding 31 October-2 November 2007, Hotel Grand chancellor Hobart, Tasmania.

Pham, T. and Peat, A. (2009) *Australian fisheries statistics 2008.* Australian Bureau of Agriculture and Resource Economics Canberra ACT.

Phillips, G., Kriwoken, L., and Hay, P. (2002) Private property and public interest in fisheries management: the Tasmanian rock-lobster fishery. *Marine Policy* 26 (6):459-469.

Potts, T. (2006) A framework for the analysis of sustainability indicator systems in fisheries. *Ocean and Coastal Management* 49:259-280.

Punt, A., Smith, D., Tuck, G., and Methot, R. (2006) Including discard data in fisheries stock assessments: two case studies for south-eastern Australia. *Fisheries and Research* 79:239-250.

Rayns, N. (2007) The government's harvest strategy policy. *ICES Journal of Marine Science* 64:596-598.

Sainsbury, K. (2008) *Best practice reference points for Australian fisheries.* A report to the Australian Fisheries Management Authority and the Department of Environment, Water, Heritage and the Arts. AFMA Report No. R2001/0999. Australian Fisheries Management Authority, Canberra, ACT.

Sainsbury, K., Punt, A., and Smith, A. (2000) Design of operational management strategies for achieving fishery ecosystem objectives. *ICES Journal of Marine Science* 57:731-741.

Sainsbury, K, Smith, A. Webb, H. (1998) C*urrent use and recommendations for future development of sustainability indicators to measure performance of Australian fisheries against ESD objectives.* FRDC project No. 98/168. Fisheries Research and Development Corporation and Commonwealth Scientific and Industrial Research Organisation, Hobart, Tasmania.

Sanchirico, J., Smith, M., and Lipton, D. (2008) An empirical approach to ecosystem-based fishery management. *Ecological Economics* 64:586-596.

Schirmer, J. (2005) ESD *Reporting and Assessment Subprogram: a social assessment handbook for use by Australian fisheries managers in ESD assessment and monitoring.* Final Report FRDC Project 2003/056. Bureau of Rural Sciences and Fisheries Research and Development Corporation, Canberra ACT.

Schirmer, J., and Casey, A. (2005) *Social Assessment Handbook: a guide to methods and approaches for assessing the social sustainability of fisheries in Australia.* FRDC ESD Reporting and Assessment Subprogram Publication No. 7. Fisheries Research and Development Corporation and Bureau of Rural Sciences, Canberra, ACT.

Seafood Experience Australia (2010) *About us,* viewed 23 February 2010 <http://www.australianseafood.com.au/aboutus/>

Seafood Services Australia (2010a) *Australian fish names standard® AS SSA 5300,* viewed 23 February 2010 <http://www.seafoodservices.com.au/page/?pid=305>

Seafood Services Australia (2010b) *About us,* viewed 23 February 2010 <http://www.seafoodservices.com.au/page/?pid=287>

Sharing the Fish Conference 06 *Conference Program overview,* viewed 23 February 2010 <http://www.fishallocation.com/>

Smith, A., Sainsbury, K., and Stevens, R. (1999) Implementing effective fisheries-management systems-management strategy evaluation and the Australian partnership approach. *ICES Journal of Marine Science* 56:967-979.

Smith, A., Fulton, E., Hobday, A., Smith, D., and Shoulder, P. (2007) Scientific tools to support the practical implementation of ecosystem-based fisheries management. *ICES Journal of Marine Science* 64:633-639.

Smith, A., Smith, D., Tuck, G., Klaer, N., Punt, A., Knuckey, I., Prince, J., Morison, A., Kloser, R., Haddon, M,, Wayte, S., Day, J., Fay, G., Pribac, F., Fuller, M., Taylor, B., and Little, L. (2008) Experience in implementing harvest strategies in Australia's south-eastern fisheries. *Fisheries Research* 94:373-379.

Smith, D. and Hodge, R. Eds. (June 2001) *ESD and fisheries: what, why, how and when.* A Stakeholders Workshop Proceedings 23-24 March 2000,Geelong Victoria. Seafood Industry Victoria Inc., South Yarra, Victoria.

Smith, D., Smith, T., Dichmont, C., Davies, C., Bodsworth, A., Gooday, P., Galeano, D., McLoughlin, K., Knuckey, I., Haddon, M., and Jackson, G. (September 2007) *Commonwealth fisheries harvest strategy: policy and guidelines* Department of Agriculture, Fisheries and Forestry, Canberra ACT.

The Allen Consulting Group (June 2004) *The economic contribution of Australia's marine industries.* Report to the National Oceans Office, Canberra, ACT.

Vieira, S., Perks, C., Mazur, K., Curtotti, R., and Li, M. (February 2010) *Impact of the structural adjustment package on the profitability of Commonwealth fisheries.* ABARE research report 10.01. Australian Bureau of Agricultural and Resource Economics Canberra, ACT.

Walters, C., and Martell, S. (2004) *Fisheries ecology and management.* Princeton University Press, Princeton, USA.

Ward, T., Heinemann, D., and Evans, N. (2001) *The role of marine reserves as fisheries management tools: a review of concepts, evidence and international experience.* Bureau of Rural Sciences, Canberra, ACT.

Ward, T., and Butler, A. (2006) *Coasts and oceans, theme commentary.* Prepared for the 2006 Australian State of the environment Committee. Department of Environment and Heritage, Canberra, ACT.

Webb, H., and Smith, T. (2008) *Review of the scope, assessment methods and management responses for fisheries ESD and EBFM in Australia.* FRDC Report 2004/101. Fisheries Research and Development Corporation and Commonwealth Scientific and Industrial Research Organisation, Hobart, Tasmania.

Whitworth, B., Chesson, J., Fletcher, W., Sainsbury, K., Fisher, M., Hundloe, T., and Smith, A.(2002) *National ESD reporting framework for Australian fisheries: Technical Support Document – Ecological Components of the 2000/2001 Case Studies.* FRDC Project 2000/145. Fisheries Research and Development Corporation, Canberra, ACT.

Williams, M., Stewart, P. (1993) Australian fisheries A*ustralian fisheries Resources.* Eds. Kailola, P., Williams, M., Stewart, P., Reichelt, R., McNee, A., and Grieve, C.

Bureau of Resource Sciences, Department of Primary Industries and Energy, and the Fisheries Research and Development Corporation, Canberra, ACT.

Wood, R., Hohnen, L., and Peat, A. (2008) *Australian fisheries statistics 2007.* Australian Bureau of Agricultural and Resource Economics, Canberra, ACT.

Yearsley, G., Last, P., and Ward, R. Eds. (1999) *Australian seafood handbook: an identification guide for domestic species.* Commonwealth Scientific and Industrial Research Organisation, Marine Research, Hobart, Tasmania.

Yearsley, G., Onley, A., and Brown, F. (2000) *Australian seafood users manual: making the most of the world's best.* The State of Queensland, Department of Primary Industries and Fisheries Research and Development Corporation, Brisbane QLD.

Yearsley, G., Last, P., and Ward, R. Eds.(2003) *Australian seafood handbook: an identification guide to imported species.* Commonwealth Scientific and Industrial Research Organisation Marine Research and Fisheries Research and Development Corporation, Hobart Tasmania.

Chapter 8

Australian Fisheries Management Authority (2005) *Researching for fisheries, industry and community: AFMAs strategic research plan 2005-2010.* Australian Fisheries Management Authority, Canberra, ACT.

Australian Fisheries Management Authority (2006) *Annual report 2005-06.* Australian Fisheries Management Authority, Canberra, ACT.

Australian Fisheries Management Authority (28 February 2006) *Future operating environment for Commonwealth fisheries.* Australian Fisheries Management Authority, Canberra, ACT.

Australian Fisheries Management Authority (2007) *Annual report 2006-07.* Australian Fisheries Management Authority, Canberra, ACT.

Australian Fisheries Management Authority (March 2007) *Southern and Eastern Scalefish and Shark Fishery bycatch action plan 2007-2009.* Australian Fisheries Management Authority Canberra, ACT.

Australian Fisheries Management Authority (2008) *School shark stock rebuilding strategy, 2008* viewed 26 February 2010 <http://www.afma.gov.au/fisheries/sess/sess/notices/2009.htm>

Australian Fisheries Management Authority (2 September 2008) *Ecosystem based fishery management,* viewed 25 February 2010 <http://www.afma.gov.au/environment/eco_based/default.htm>

Australian Fisheries Management Authority (November 2008) *Great Australian Bight Trawl Fishery bycatch and discarding workplan.* Australian Fisheries Management Authority Canberra, ACT.

Australian Fisheries Management Authority (2009) *Annual report 2008-09.* Australian Fisheries Management Authority, Canberra, ACT.

Australian Fisheries Management Authority (3 February 2009) *Ecological Sustainable Development*, viewed 25 February 2010 <http://www.afma.gov.au/environment/esd/default.htm>

Australian Fisheries Management Authority (1 June 2009) *Great Australian Bight Trawl sector Management Advisory Committee (GABMAC) meeting 1/2009 on 28 May 2009, Canberra.* Agenda item 3.1, viewed 26 February 2010 <http://www.afma.gov.au/fisheries/sess/sess_gab/mac/2009/gabmac_1-2009.htm>

Australian Fisheries Management Authority (17 June 2009) *Ecological Risk Management*, viewed 26 February 2010 <http://www.afma.gov.au/environment/eco_based/eras/risk.htm>

Australian Fisheries Management Authority (25 August 2009) *Southern and Eastern Scalefish and Shark Fishery*, viewed 25 February 2010 <http://www.afma.gov.au/fisheries/sess/sess/default.htm>

Australian Fisheries and Management Authority (29 September 2009) *Managing Bycatch and discarding,* viewed 1 March 2010 <http://www.afma.gov.au/environment/bycatch/default.htm>

Australian Fisheries Management Authority (4 December 2009) *Protected species,* viewed 1 March 2010 <http://www.afma.gov.au/environment/eco_based/reporting.htm#factsheets>

Australian Fisheries Management Authority (4 January 2010) *Orange Roughy Conservation Programme,* viewed 26 February 2010 <http://www.afma.gov.au/fisheries/sess/sess/notices/2006.htm>

Australian Fisheries Management Authority (25 January 2010) *Bycatch action progress reports and bycatch and discard workplans1 July 2009 to 30 June 2011,* viewed 1 March 2010 <http://www.afma.gov.au/information/publications/fishery/baps/default.htm>

Australian Fisheries Management Authority (4 February 2010) *Corporate Plan,* viewed 23 February 2010 <http://www.afma.gov.au/information/publications/corporate/corporate_plan/default >

Australian Fisheries Management Auhtority (8 February 2010) *Ecological risk management,* viewed 26 February 2010 <http://www.afma.gov.au/environment/eco_based/eras/reports.htm>

Bellchambers, L. (2010) *The effects of western rock lobster fishing on the deepwater ecosystems of the west coast of Western Australia.* FRDC Report No. 2004/049. Fisheries Research Report No. 199. Department of Fisheries, Perth, Western Australia.

Bennett, E. (2005) Success in fisheries management: a review of the literature in *Successful fisheries management: issues, case studies and perspectives.* Eds. Cunningham, S., and Bostock, T. Eburon Academic Publishers, Delft, The Netherlands.

Bostock, T (2005) Preface in *Successful fisheries management: issues, case studies and perspectives.* Eds. Cunninham, S., and Bostock, T. Eburon Academic Publishers, Delft, The Netherlands.

Brady, M. and Waldo, S. (2009) Fixing problems in fisheries integrating ITQs, CBM and MPAs in management. *Marine Policy* 33:258-263.

Bray, T., Gill, S., and Edwards, R. (January 2006) A*ssessment of western rock lobster strategic management options: how do quota management systems work in rock lobster fisheries. A comparative analysis of experience in New Zealand, Tasmania and South Australia Volume 4.* Fisheries Management Paper 212. Department of Fisheries, Perth, Western Australia.

Brown, R. (September 2009) *Western Rock Lobster Low Puerulus Settlement Risk Assessment.* Draft Report for public comment. Workshop held 1 and 2 April 2009 Department of Fisheries. Fisheries Occasional Paper No. 71. Department of Fisheries, Perth, Western Australia.

Buxton, C., Haddon, M and Bradshaw, M. (February 2006) *Regional impact assessment for the Marine Protected Areas proposed for the South-East Region.* FRDC 2005/083. The Tasmanian Aquaculture and Fisheries Institute, Tasmania.

Caputi, N. and Lenanton, R. (2009) The effects of climate change on fisheries in Western Australia in *A changing climate: Western Australia in focus.* Symposium presenters' abstract papers, 27 March 2009, University Club of Western Australia, Perth Australia.

CDI Pinnacle Management Pty Ltd. (18 June 2007) *Southern and Eastern Scalefish and Shark Fishery supply chain analyses.* Prepared for Department of Agriculture, Fisheries and Forestry (DAFF 73/06). CDI Pinnacle Management Pty Ltd., Milton, Queensland.

Commonwealth of Australia (Gazetted 20 December 2005) *Ministerial Direction.* Commonwealth of Australia Gazette No S234. Commonwealth of Australia, Canberra, ACT.

Consultation Working Group (July 2009) *Report of the Consultation Working Group.* Department of Fisheries, Perth, Western Australia.

Cunningham, S. (2005a) Overview in *Successful fisheries management: issues, case studies and perspectives.* Eds. Cunninham, S., and Bostock, T. Eburon Academic Publishers, Delft, The Netherlands.

Cunningham, S. (2005b) Conclusions: factors for success in fisheries management in *Successful fisheries management: issues, case studies and perspectives.* Eds. Cunninham, S., and Bostock, T. Eburon Academic Publishers, Delft, The Netherlands.

de Lestang, S., Melville-smith, R.,Thomson, A., and Rossbach, M. (2008) Fisheries, West Coast Rock Lobster Fishery status report in *State of the fisheries report 2007/08.* Eds. Fletcher, W., and Santoro, K. Department of Fisheries, Perth, Western Australia.

de Lestang, S., Thomson, A., and Rossbach, M. (2009) Fisheries West Coast Rock Lobster Fishery status report in *State of the fisheries report 2008/09.* Eds. Fletcher, W., and Santoro, K. Department of Fisheries, Perth, Western Australia.

Department of Agriculture Fisheries and Forestry Australia (June 2003) *Looking to the future: a review of Commonwealth fisheries policy*. Commonwealth Department of Agriculture Fisheries and Forestry Australia, Canberra, ACT.

Department of Agriculture, Fisheries and Forestry (26 October 2009) *Securing our fishing future,* viewed 25 February 2010 <http://www.daff.gov.au/fisheries/domestic/fishingfuture>

Department of Fisheries (December 2004) *Commercial fisheries of WA Western Rock Lobster,* viewed 2 March 2010 <http://www.fish.wa.gov.au/docs/cf/RockLobster/index.php?0206#a02>

Department of Fisheries (1 October 2004 updated 2009) *Integrated Fisheries Management Government Policy.* Department of Fisheries Western Australia, viewed 1 March 2010 <http://www.fish.wa.gov.au/docs/pub/IFMGovtPolicy/download.php?0601>

Department of Fisheries (March 2005) *Western Rock Lobster Environmental Management Strategy July 2002 - June 2006.* Department of Fisheries, Perth, Western Australia.

Department of Fisheries (January 2006) *Assessment of Western rock lobster strategic management options: an overview of bio-economic, sociological and comparative analyses Volume 1*. Fisheries Management Paper no. 209. Department of Fisheries, Perth, Western Australia.

Department of Fisheries (June 2006) *A guide to Integrated Fisheries Management (IFM) Government Policy*. Department of Fisheries, Perth, Western Australia.

Department of Fisheries (October 2006) *Matters relevant to the development of a sustainable allocation and grow out model for Western Rock Lobster pueruli: a scoping paper*. Fisheries Management Paper No.219. Department of Fisheries, Perth, Western Australia.

Department of Fisheries (2008) *Department of Fisheries annual report to Parliament 2007/08*. Department of Fisheries, Perth, Western Australia.

Department of Fisheries (2009) *Department of Fisheries annual report to Parliament 2008/09.* Department of Fisheries, Perth, Western Australia.

Department of Fisheries (13 February 2009) letter ref.15/09, viewed 15 June 2009 <http://www.fish.wa.gov.au/docs/pub/CommRLChanges09/index.php?0206>

Department of Fisheries (October 2009) *Research and development plan 2009/10.* Department of Fisheries, Perth, Western Australia.

Department of Fisheries (December 2009) *West Coast Rock Lobster Newsletter,* viewed 4 March 2010 <http://www.fish.wa.gov.au/sec/com/fisheries/WCRockLobster.php?0206>

Department of Fisheries (January 2010) *West Coast Rock Lobster Fishery*, viewed 2 March 2010 <http://www.fish.wa.gov.au/sec/com/fisheries/WCRockLobster.php?0206>

Department of Primary Industries and Energy (1989) *New directions for Commonwealth fisheries management in the 1990: a Government Policy statement December 1989.* Australian Government Publishing Service, Canberra, ACT.

Ecological Effects of Fishing Scientific Reference Group (December 2006) *Western Rock Lobster effects of fishing research plan.* Fisheries Occasional Publication No. 39. Department of Fisheries, Perth, Western Australia.

Economic Research Associates Pty Ltd. (January 2006) A*ssessment of Western rock lobster strategic management options: a bio-economic evaluation of management options for the West Coast Rock Lobster Fishery Volume 2.* Fisheries Management Paper No. 210. Department of Fisheries, Perth, Western Australia.

Fisheries Research Division (February 2009) *Research and development plan 2008-09.* Fisheries Occasional Publication No. 58. Department of Fisheries, Perth, Western Australia

Fletcher, W., and Santoro, K. eds. (2008) *State of the fisheries report 2007/08.* Department of Fisheries, Perth, Western Australia.

Fletcher, W., and Santoro, K. Eds. (2009) *State of the fisheries report 2008/09.* Department of Fisheries, Perth, Western Australia.

Funding Working Group (July 2009) *Report of the Funding Working Group.* Department of Fisheries, Perth, Western Australia.

Government of Western Australia (24 September 2009) *Ministerial Media Statement,* viewed 4 March 2010 <http://www.fish.wa.gov.au/sec/com/fisheries/WCRockLobster.php?0206>.

Grafton, R., and McIlgorm (2009) *Ex ante* evaluation of the costs and benefits of individual transferable quotas: a case-study of seven Australian Commonwealth fisheries. *Marine Policy* 33:714-719.

Hobday, A., Okey, T., Poloczanska, E., Kunz, T., and Richardson, A. Eds. (September 2006a) *Impacts of climate change on Australian marine life: Part A Executive Summary.* Report to the Australian Greenhouse Office. Australian Greenhouse Office, Canberra, ACT.

Hobday, A., Okey, T., Poloczanska, E., Kunz, T., and Richardson, A. Eds. (September 2006b) *Impacts of climate change on Australian marine life: Part B Technical Report.* Report to the Australian Greenhouse Office. Australian Greenhouse Office, Canberra, ACT.

Hobday, A., Poloczanska, E., and Matear, R. Eds. (2008) *Implication of climate change for Australian fisheries and aquaculture: a preliminary assessment.* Report to the Department of Climate Change. Department of Climate Change, Canberra, ACT.

Hohnen, L., Wood, R., Newton, P., Jahan, N., and Vieria, S. (2008) *Fishery economic status report 2007.* ABARE Report 08.10, prepared for the Fisheries Resources Research Fund, Canberra, ACT.

Huddleston, V. (January 2006) A*ssessment of Western rock lobster strategic management options: a social assessment of coastal communities hosting the West Coast Rock Lobster fishing fleet Volume 3.* Fisheries Management Paper No. 211. Department of Fisheries, Perth, Western Australia.

Larcombe, J., and Begg, G. Eds. (2008) *Fishery status reports 2007: status of fish stocks managed by the Australian government Australian.* Bureau of Rural Sciences, Canberra, ACT.

McLoughlin, K., and Wood, R. (2009) Shark Gillnet and Shark Hook sectors in *Fishery status reports 2008.* Eds.Wilson, D., Curtotti, R., Begg, G., and Phillips, K. Bureau of Rural Sciences and Bureau of Agricultural and Resource Economics, Canberra, ACT.

Melville-Smith, R., Johnston, D., Johnston, B., and Thomson, N. (2008) *Identifying obstacles to profitability growing out Western Rock Lobsters.* A report prepared for the Aquaculture Development Council. Fisheries Research Report No.172. Department of Fisheries, Perth, Western Australia.

Melville-Smith, R., Johnston, D., Maguire, G., and Phillips, B. (2009) *Establishing post-pueruli growout data for Western Rock Lobsters.* Final Fisheries Research and Development Corporation on Report No. 2003/213. Fisheries Research Contract Report No. 19. Department of Fisheries, Perth, Western Australia.

Metcalf, S., Gaughan, D., and Shaw, J. (2009) *Conceptual models for Ecosystem Based Fisheries Management (EBFM) in Western Australia.* Fisheries Research Report No.194. Department of Fisheries, Perth, Western Australia.

Ming, F. (2009) Physical environmental changes off the Western Australian coasts and the potential impacts on marine ecosystems in *A changing climate: Western Australia in focus.* Symposium presenters' abstract papers, 27 March 2009. University Club of Western Australia, Perth, Australia.

Minnegal, M., and Dwyer, P. (2008) Mixed messages: buying back Australia's fishing industry. *Marine Policy* 32:1063-1071.

Morgan, G.(February 2009) *Review of the draft paper proposed quota settings for the Western Rock Lobster Fishery.* Fisheries Occasional Publication No.59. Department of Fisheries, Perth, Western Australia.

Morgan, G., Gardner, C., Edwards, R., and Cartwright, I. (June 2009a) *A quota management system for the Western Rock Lobster Fishery.* An independent report commission by the Rock Lobster Industry Advisory Committee (RLIAC). Fisheries Occasional Publication No. 68. Department of Fisheries, Perth, Western Australia.

Morgan, G., Gardner, C., Edwards, R., and Cartwright, I. (June 2009b) *An input control management System for the Western Rock Lobster Fishery.* An independent report commission by the Rock Lobster Industry Advisory Committee (RLIAC). Fisheries Occasional Publication No 69. Department of Fisheries, Perth, Western Australia.

Morison, A., (2008) Southern and Eastern Scalefish and Shark Fishery overview in *Fishery status reports 2007.* Eds. Larcombe, J., and Begg, G. Bureau of Rural Sciences and Bureau of Agricultural and Resource Economics, Canberra, ACT.

Morison, A., and McLoughlin, K. (2008) Commonwealth trawl and scalefish-hook sectors in *Fishery status reports 2007.* Eds. Larcombe, J., and Begg, G. Bureau of Rural Sciences and Bureau of Agricultural and Resource Economics, Canberra, ACT.

Morison, A., Patterson, H., and Pham, T. (2009a) Great Australian Bight Trawl sector in *Fishery status reports 2008.* Eds. Wilson, D., Curtotti, R., Begg, G., and Phillips, K. Bureau of Rural Sciences and Bureau of Agricultural and Resource Economics, Canberra, ACT.

Morison, A., Patterson, H., and Vieira, S. (2009b) Southern and Eastern Scalefish and Shark Fishery overview in *Fishery status reports 2008.* Eds. Wilson, D., Curtotti, R., Begg, G., and Phillips, K. Bureau of Rural Sciences and Bureau of Agricultural and Resource Economics, Canberra, ACT.

Morison, A. Patterson, H., Sampaklis, A., Wood, R., and Vieira, S. (2009c) Commonwealth Trawl and Scalefish Hook sectors in *Fishery status reports 2008.* Eds. Wilson, D., Curtotti, R., Begg, G., and Phillips, K. Bureau of Rural Sciences and Bureau of Agricultural and Resource Economics, Canberra, ACT.

Newton, P., Wood, R., Galeano, D., Vieira, S., and Perry, R.(October 2007) *Fisheries economic status report*. ABARE Report 07.19 Prepared for the Fisheries Resources Research Fund, Canberra, ACT.

Pascoe, S., and Gibson, T. (2009) Do boat licences have a role in fisheries managed through individual quotas? Experience in Australian fisheries. *Marine Policy* 33 (2):297-304.

Patterson, H., and Pham, T. (2009) East Coast Deepwater Trawl sector in *Fishery status reports 2008.* Eds. Wilson, D., Curtotti, R., Begg, G., and Phillips, K. Bureau of Rural Sciences and Bureau of Agricultural and Resource Economics, Canberra, ACT.

Patterson, H. and Tudman, M. (September 2009) *Chondrichthyan guide for fisheries managers: a practical guide for mitigating chondrichthyans bycatch.* Bureau of Rural Sciences and Australian Fisheries Management Authority, Canberra, ACT.

Pham , T., and Peat, A. (2009) *Australian fisheries statistics 2008.* Australian Bureau of Agricultural and Resource Economics, Canberra, ACT.

Phillips, B., Melville-Smith, M., Rossbach, M., Cheng, Y., Caputi, N., Thompsonn, A., Mills, D., and Crear, B. (2003) *Towards establishing techniques for large scale harvesting of pueruli and obtaining a better understanding of mortality rates.* FRDC Project 1998/302. Rock Lobster Enhancement and Aquaculture Subprogram. Fisheries Research Report No. 144. Department of Fisheries, Perth, Western Australia.

Reid, C. (February 2009) *An analysis of maximum economic yield in the Western Rock Lobster Fishery.* Fisheries Occasional Publication No.60. Department of Fisheries, Perth, Western Australia.

Reid, C. (January 2010) *Potential reallocation mechanisms for the transfer and/or adjustment of catch shares between sectors with application to the Western and South Australian rock lobster fisheries.* Fisheries Management Paper No. 238. Department of Fisheries, Perth, Western Australia.

Rock Lobster Industry Advisory Committee (May 2008) *West Coast Rock Lobster managed fishery: recommended management changes for the 2008-09 season.* Fisheries Occasional Publication No. 49. Rock Lobster Industry Advisory Committee, Perth, Western Australia.

Rock Lobster Industry Advisory Committee (6 July 2009) *Letter to the Minister.* Department of Fisheries, viewed 2 March 2010 <http://www.fish.wa.gov.au/docs/pub/CommRLChanges09/index.php?0206>

Rogers, P. (2009) Introduction in *A changing climate: Western Australia in focus.* Symposium presenters' abstract papers, 27 March 2009, University Club of Western Australia, Perth Australia.

Scientific Certification Systems Inc. (12 December 2006) *MSC Assessment: the Western Australia Rock Lobster Fishery.* Scientific Certification Systems Inc. Emeryville, CA, USA.

Scientific Certification Systems Inc. (3 July 2009) *Western Australian Rock Lobster Fishery 2009 MSC.* Scientific Certification Systems Inc., Emeryville, CA, United States.

Scientific Certification Systems (December 2009) *Western Australian Rock Lobster Fishery 2009 MSC special/surveillance audit report.* Scientific Certification Systems Inc., Emeryville, CA, United States.

Smith, A., and Smith, D. (2001) A complex quota-managed fishery: science and management in Australia's South-east Fishery. *Marine and Freshwater Research* 52 (4): 353-360.

Smith, A., and Smith, D. (June 2005) *A harvest strategy framework for the SESSF.* Report to the Australian Fisheries Management Authority, Canberra, ACT.

Smith, A., Smith, D., Tuck, G., Klaer, N., Punt, A., Knuckey, I., Prince, J., Morison, A., Kloser, R., Haddon, M,, Wayte, S., Day, J., Fay, G., Pribac, F., Fuller, M., Taylor, B., and Little, L. (2008) Experience in implementing harvest strategies in Australia's south-eastern fisheries. *Fisheries Research* 94(3):373-379.

Stoklosa, R. (2007) *Western Rock Lobster ecological risk assessment.* Prepared for the Department of Fisheries WA. Fisheries Occasional Publication No. 56. E-Systems Pty Ltd., Hobart, Tasmania.

Vieira, S., Wood, R., and Causer, T. (October 2008) *Australian fisheries surveys report 2008: results for selected fisheries 2005-06 and 2006-07.* Australian Bureau of Agriculture and Resource Economics, Canberra, ACT.

Vieira, S., Perks, C., Mazur, K., Curtotti, R., and Li, M. (February 2010) *Impact of the structural adjustment package on the profitability of Commonwealth fisheries.* ABARE research report 10.01. Australian Bureau of Agricultural and Resource Economics Canberra, ACT.

Western Rock Lobster Council Inc. (July 2007) *Improving the economic efficiency of the Western Rock Lobster Fishery.* Western Rock Lobster Council Inc., Osborne Park, Western Australia.

Western Rock Lobster Development Association (2007) *About us*, viewed 2 March 2010 <http://www.western-rock-lobster.com/aboutus.htm>

Wilson, D., Curtotti, R., Leatherbarrow, A., Bensley, N., and Pham, T. (2009) Overview in *Fishery status reports 2008.* Eds. Wilson, D., Curtotti, R., Begg, G., and

Phillips, K. Bureau of Rural Sciences and Bureau of Agricultural and Resource Economics, Canberra, ACT.

Wood, R., Hohnen, L., and Peat, A. (2008) *Australian fisheries statistics 2007*. Australian Bureau of Rural Sciences and Fisheries Research and Development Corporation, Canberra, ACT.

Acts

Environment Protection and Biodiversity Conservation Act 1999

Fisheries Management Act 1991

Fisheries Resource Management Act 1994

Pearling Act 1990

Chapter 9

Allison G.W., Lubchenco J., and Carr M.H. (1998) Marine reserves are necessary but not sufficient for marine conservation. *Ecological Applications,* 8 (1) Supplement, s79-s92.

Australian State of the Environment Committee (2001) *Australia state of the environment 2001.* An independent report to the Commonwealth Minister for the Environment and Heritage. Commonwealth Scientific and Industrial Research Organisation, Collingwood, Victoria.

Bavinck, M., Chuenpagdee, R., Diallo, M., van der Hiejden, P., Kooiman , J., Mahon, R., and Williams, S. (2005) *Interactive fisheries governance: a guide to better practice.* Eburon Academic Publishers, Delft, The Netherlands.

Beeton, R., Buckley, K., Jones, G., Morgan, D., Reichelt, R., E, Trewin, D. (2006) *Australia state of the environment 2006.* An independent report to the Australian Government Minister for the Environment and Heritage. Department of the Environment and Heritage, Canberra, ACT.

Brinsmead, T (2005) *Integrated sustainability assessment: identifying methodological options,* viewed 4 March 2010 <http://pandora.nla.gov.au/pan/53596/20051027/www.naf-forum.org.au/papers/Methodology-Brinsmead.pdf>

Cicin-Sain, B., and Belfiore, S. (2005) Linking marine protected areas to integrated coastal and ocean management: a review of theory and practice. *Ocean and Coastal Management* 48:847-868.

Duinker, P., and Greig, L. (2007) Scenario analysis in environmental impact assessment: improving explorations of the future. *Environmental Impact Assessment Review* 27:206-219.

Ehler, C. (2005) Integrating management of marine protected areas with coastal and ocean governance: principles and practices. *Ocean and Coastal Management* 48:843-846.

Ecosystem Principles Advisory Panel (EPAP) (1999) *Ecosystem-based fishery management.* A report to Congress by EPAP. National Marine Fisheries Services, Silver Spring, Maryland.

Fletcher, W. (2005b) *ESD Reporting and Assessment Subprogam: strategic planning, project management and adoption.* Final Report FRDC Project No. 2001/082. Fisheries Research and Development Corporation, Canberra, ACT.

Fletcher, W., Chesson, J., Sainsbury, K., Hundloe, T., and Fisher, M. (2005) A flexible and practical framework for reporting on ecologically sustainable development for wild capture fisheries. *Fisheries Research* 71:175-183.

Food and Agricultural Organisation (FAO) of the United Nations (2003) *Fisheries management. 2. The ecosystem approach to fisheries.* FAO Technical Guidelines for responsible fisheries No.4, Supplement 2. FAO, Rome.

Garcia, S., and Charles, A. (2008) Fishery systems and linkages: implications for science and governance. *Ocean and Coastal Management* 51:505-527.

Grafton, R., Kompas, T., McLoughline, R., and Rayns, N. (2007) Benchmarking for fisheries governance. *Marine Policy* 31:470-479.

Grafton, R., Hilborn, R., Ridgeway, L., Squires, D., Williams, M., Garcia, S., Groves, T., Joseph, J., Kelleher, K., Kompas, T., Libecap, G., Lundin, C., Makino, M., Matthiasson, T., Mcloughlin, R., Parma, A., Martin, G., Satia, B., Schmidt, C., Tait, M., and Zhang, L. (2008) Positioning fisheries in a changing world. *Marine Policy* 32:630-634.

Hanna, S. (1999) Strengthening governance of ocean fishery resources. *Ecological Economic* 31:275-286.

Jentoft S. (2004) Institutions in fisheries: what they are, what they do, and how they change. *Marine Policy* 28:137-149.

Joseph, J., Kelleher, K., Kompas, T., Libecap, G., Lundin, C., Makino, M., Matthiasson, T., Mcloughlin, R., Parma, A., Martin, G., Satia, B., Schmidt, C., Tait, M., and Zhang, L. (2008) Positioning fisheries in a changing world. *Marine Policy* 32:630-634.

Kailola, P., Williams, M., Stewart, P., Reichelt, R., McNee, A., Grieve, C. (1993) *Australian fisheries Resources.* Bureau of Resource Sciences, Department of Primary Industries and Energy and the Fisheries Research and Development Corporation, Canberra, ACT.

Kooiman, J., and Jentoft, S. (2005) Hard choices and values in *Fish for life: interactive governance for fisheries.* Eds. Kooiman, J., Bavinck, M., Jentoft, S., and Pullin, R. MARE Publication Series No.3. Amsterdam University Press, Amsterdam.

Korn, H., Schliep, R., and Stadler, J. (Eds.) (2003). *Report of the international workshop on the further development of the ecosystem approach.* BfN-Skrpten 78. Bundesmat fur Naturschutz (BfN), Federal Agency for Nature Conservation, Germany.

Leadbitter, D., and Ward, T. (2007) An evaluation of systems for integrated assessment of capture fisheries. *Marine Policy* 31:458-469.

Meadowcroft, J. (2002) Politics and scale: some implications for environmental governance. *Landscape and Urban Planning* 61:169-179.

Pikitch, E., Santora, C., Babcock, E., Bakun, A., Bonfil, R., Conover, D., Dayton, P., Doukakis, P., Fluharty, D., Heneman, B., Houde, E., Link, J., Livingston, P., Mangel, M., McAllister, M., Pope, J., and Sainsbury, K. (2004) Ecosystem-based fishery management. *Science* 305: 346-347.

Rudd, M. (2004) An institutional framework for designing and monitoring ecosystem-based fisheries management policy experiments. *Ecological Economics* 48:109-124.

Sanchirico, J., Smith, M., and Lipton, D. (2008) An empirical approach to ecosystem-based fishery management. *Ecological Economics* 64:586-596.

Sainsbury, K. and Sumaila, U. (2003) Incorporating ecosystem objectives into management of sustainable marine fisheries, including best practice reference points and use of marine protected areas in *Responsible fisheries in the marine ecosystem.* Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

Sainsbury, K, Smith, A. Webb, H. (1998) C*urrent use and recommendations for future development of sustainability indicators to measure performance of Australian fisheries against ESD objectives.* FRDC project No. 98/168. Fisheries Research and

Development Corporation and Commonwealth Scientific and Industrial Research Organisation, Hobart, Tasmania.

Sissenwine, M. and Mace, P. (2003) Governance for responsible fisheries: an ecosystem approach in *Responsible fisheries in the marine ecosystem.* Eds. Sinclair, M. and Valdimarsson, G. FAO and CABI Publishing, London.

State of the Environment Advisory Council (1996) *Australia state of the environment 1996.* An independent report presented to the Commonwealth Minister for the Environment. Commonwealth Scientific and Industrial Research Organisation, Collingwood, Australia.

Symes, D. (2006) Fisheries governance: a coming of age for fisheries social science. *Fisheries Research* 81:113-117.

Symes, D. (2007) Fisheries management and institutional reform: a European perspective. *ICES Journal of Marine Science* 64:779-785.

Tonn, B. (2007) Futures sustainability *Futures* 39:1097-1116.

Ward, T., Tarte, D., Hegerl, E., Short, K. (June 2002) *Policy proposals and operational guidance for Ecosystem-Based Management of marine capture fisheries.* World Wide Fund for Nature (WWF) Australia.

Webb, H., and Smith, T. (2008) *Review of the scope, assessment methods and management responses for fisheries ESD and EBFM in Australia.* FRDC Report 2004/101. Fisheries Research and Development Corporation and Commonwealth Scientific and Industrial Research Organisation, Hobart, Tasmania.

Wilber, K. (1997) *The eye of spirit: an integral vision for a world gone slightly mad.* Shambala Publishing Inc., Boston, Massachuesetts.

Zann, L. (1995) *Our sea our future major findings of State of the marine environment report for Australia.* For the Department of the Environment, Sport and Territories, Canberra, ACT.

APPENDIX 1: PERMISSION FORMS

This statement is to confirm the proportional authorship of the co-authored report: Webb, H.; and Smith, T. (2008) *Review of the scope, assessment methods and management responses for fisheries ESD and EBFM in Australia* FRDC Report 2004/101. Fisheries Research and Development Corporation and Commonwealth Scientific and Industrial Research Organisation, Hobart, Tasmania (invited Research Project, Fisheries Research and Development Corporation).

The proportional authorships is estimated as Helen Webb ninety five percent and Tony Smith at five percent.

The co-author grants Helen Webb permission to use the information published in the co-authored report that she has written or contributed to, in the content and background of this thesis.

Helen Webb

Tony Smith

Date: 23rd August 2010