Sustainability Indicators in Marine Capture Fisheries

By

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Declaration

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. To the best of my knowledge and belief, this thesis contains no material previously published or written by another person except where due acknowledgement is made in the text.

Tavis William Potts
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Abstract

This thesis examines the development of sustainability indicator systems (SIS) as a tool to implement the concept of sustainability into fisheries management. This research focuses upon the identification and evolution of these systems, their application as a management tool, and their response to problems in fisheries sustainability. The thesis presents a series of ten case studies that outline differing approaches to developing SIS in marine capture fisheries. These national, regional and non-government case studies provide an opportunity to strategically assess and evaluate the use of SIS in fisheries management.

The United Nations Conference on Environment and Development in 1992 addressed sustainable development as a means to satisfy the needs of human societies within the constraints presented by natural systems. Over the last ten years, sustainable development has been adopted by local, regional, national, and international institutions and instruments. Implementing and operationalising the concept of sustainable development has, however provided significant challenges.

Marine capture fisheries witnessed rapid development in the second half of the 20th Century. As pressure increases on capture fisheries, it is important that measures are introduced to ensure sustainable use of such fisheries. These measures include methodologies and frameworks for the assessment and management of fisheries incorporating biological, environmental, economic and socio-political relationships – the core of sustainable development. This thesis examines the viability of sustainability indicators as a tool for assessing progress towards sustainability. Indicator systems have been implemented across a range of fisheries jurisdictions with varying degrees of success.

In assessing SIS in practice, several key components were distilled from the case studies and the assessment framework. The research demonstrates that SIS are used in national environmental reporting and fisheries specific systems across a range of legal and policy contexts, can link directly to the fisheries management process, and focus at the scale of fishery operations. Target species indicators are well advanced in SIS practice, ecosystem indicators are being rapidly developed and tested, and socio-economic and governance indicators require further progress. In terms of addressing sustainability outcomes, SIS are shown to facilitate scientific and policy coordination, increase transparency, accountability and co-management, increase the participation of environmental and non-government organisations, and provide the structure to implement ecosystem based management and precautionary approaches. While some SIS have been successful in developing measurement frameworks, criteria, objectives and indicators and adapting to specific policy contexts, further progress is required in developing reporting protocols, visualisation tools and aggregation methods.

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If we could first know where we are, and whither we are tending, we could better judge what to do, and how to do it…

- Abraham Lincoln

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Introduction

Everything should be as simple as possible, but not simplistic.

- Albert Einstein

The concept of sustainable development has emerged as a key guiding principle and action agenda for all forms of environmental management, economic development, and social justice at international, regional, national, sub-national and local levels. The 'triple bottom line' has revolutionised the way we see and interact with the world and each other, and attempts to set a course for an increasingly innovative future based on conservation and protection, wise resource use, social equity, economic growth and stability. The concept emerged in the late 1980s with groundbreaking international reports such as *Our Common Future* and in the early 1990s with the negotiation of the UN Declaration on Environment and Development and its product: Agenda 21.

Sustainability implies that all socio-economic (human based) systems and ecological (natural based) systems should remain in a healthy and viable state, so that benefits can flow to current and future generations. This includes the orientation of development activities to within the carrying capacity of the natural environment to ensure ongoing resource availability and environmental services. Management for sustainability should, therefore, consider integrated approaches, ecosystem scales, and socio-economic considerations. Initially ideas of sustainability were promoted when the effects of environmental degradation were becoming increasingly visible across the globe. Poverty, population pressure, unequal resource distribution and trade were identified as the base causes of environmental degradation in developing countries, which required a new development approach to create sustainable economies. Sustainable development was also viewed as entirely relevant to the developed nations with the concept highlighting integrated aspects of conservation and economic growth, technology and information transfer, energy, food supply, security, transport and pollution control.

The fisheries sector has been dramatically altered by the concept of sustainability. Over the last century activities have intensified from local scale to a global market industry that employs millions and is a source of income and food for many nations. After modernisation and industrialisation of the sector, distant water fleets have been able to circumnavigate the globe in sourcing fisheries stocks, often with severe consequences for offshore species or conflicts with localised and community based fisheries. In addition, with increasing coastal state control and rights over living marine resources after the signing of United Nations Convention of the Law of the Sea in 1982, the capacity of fishing effort for domestic based fisheries has dramatically increased in national EEZs, leading to further pressures on the stocks.

As a result marine and freshwater living resources are under stress, with many showing signs of degradation and collapse as a result of overcapacity and destructive fishing practices. Modern day examples exist of the detrimental collapse of major fisheries, including the Canadian groundfish stocks and the Peruvian anchovy. Current statistics clearly display that the global capacity of the ocean to produce wild harvests is at its maximum sustainable limit. The statics from the country with the highest catches, China, have been rigorously debated with claims of over inflation of catch rates making an overall decline (FAO 2002). In addition the broader ecosystems have been detrimentally affected, especially species that are associated with, or dependent on, target stocks. Bycatch and habitat degradation remain two crucial issues for modern fisheries management, with bycatch forming up to a quarter of the total world catch. The increased impact of Illegal, Unreported and Unregulated fisheries (IUU) further adds to stress on the global supply and the viability of marine ecosystems.

The current challenge for the fisheries sector is to interpret and practically apply the concept sustainability into fisheries practice. In the ten years from UNCED legislation and policy has orientated the concept at a strategic level, but in general, minimal progress has been made to apply sustainability concerns at an operational level. This includes the translation of broad sustainability objectives into functional, pragmatic and measurable outcomes that can be applied to progress towards integrated, ecosystems-based, and ultimately more sustainable fisheries systems. The process of developing sustainability indicators is increasingly seen as a useful and practical process to incorporate ecosystem management and precautionary concerns into fisheries management operations, both key elements of developing a sustainable approach to management of resources. Indicators, and the organising systems[1] they are a part of represent a means of conceptualising broader objectives into management outcomes, provide a system of objective measurement and a means for assessing progress, and provide a pragmatic tool for

[1] Termed sustainability indicator systems, or SIS.

encouraging cooperation, participation and scientific input into management. Indicators have increasingly been seen as a tool that is useful for ‘building in’ sustainability into a variety of sectors, with recent efforts in the last five years to pursue this process with fisheries.

Indicators fulfil a variety of roles in fisheries systems, and can be adapted to a particular use or set of users. This includes public education, performance assessment, meeting legislative and policy goals, broadening the base of management, increasing participation and coordination, management certification and environmental reporting. Indicator systems in the fishing sector are characterised by recognition of their utility, but generally hampered by a lack of information, data and uneven distribution of implementation across jurisdictions. Often one part of the indicator system has been established (e.g. the objectives) while the other components remain neglected (e.g. feedback mechanisms). In addition, identification of the critical processes and challenges to indicator applications in a variety of fisheries contexts and strategic assessment of the current ‘state of play’ of practice has been generally lacking in the available research to date.

Research Aims

This thesis sets out to address the following aim:

To identify, investigate and strategically assess the use of indicator systems as tools for achieving and implementing sustainable development in a variety of marine capture fishery jurisdictions.

This can be divided into three specific objectives:

1. ***Identify the generic structures, processes and concepts that underlie indicator systems and influence their effectiveness. What are indicator systems?***
2. ***Investigate the application of indicator systems within a variety of fisheries jurisdictions and contexts. How are indicator systems applied in management?***
3. ***Strategically assess the role of indicator systems across fisheries jurisdictions. Do SIS improve outcomes in terms of sustainability?***

Study Rationale

Chapter 40 of Agenda 21 highlighted the critical importance of the need to improve information for sustainable development (United Nations 1993). A part this process was seen as the identification of indicators as tools to support decision making though the distillation of broad objectives into measurable parameters. The generation of information to support indicator development will therefore directly support the implementation of sustainability.

With this recognition a number or programs have emerged to promote and develop indicators at all scales of activity and policy. Some of these have been broad international reporting initiatives, or national and sub-national in scale. [2] In addition, indicator initiatives have appeared at sectoral scales, becoming increasingly specific addressing the needs of particular industries. As a result, the fishing sector has emerged to become a leading player in the development and use of indicators as a management tool to implement sustainable practices. As the sector has moved to identify and translate sustainability into practice and has grappled with the implementation of ecosystem-based management and precautionary approaches, indicators have been identified as a useful tool to galvanise action.

As a result of this recognition, sustainability indicators have become endorsed as a fisheries management tool. This has fuelled wide speculation and interpretation of what constitutes an indicator and the process used to develop an indicator based reporting system. Consequentially the development of indicator systems has been uneven across jurisdictions. Research effort has focused upon the development of organisational frameworks and the elaboration of objectives and indicator measurements. The identification of objectives in relation to the broader notion of sustainability has proven difficult for fisheries managers, and a general lack of data for the construction of indicators has hindered progress and become the focus of several research efforts. Several key areas of improvement have been identified in this thesis including research into the visualisation, aggregation, and communication of indicator results and the use of management feedback loops.

The process of developing an indicator system appears to be widely endorsed but insufficiently understood by management agencies. Understanding the development and application of indicators within a systems context will benefit their comprehensive development and focus on a coordinated approach to generating effective indicator systems. Any indicator initiative can be assessed and evaluated against this systems approach. In addition there is an identified need for a holistic examination of initiatives from a variety of fisheries jurisdictions (national, international and non-government) to learn the valuable lessons that apply when using indicators in different areas.

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[2] A detailed examination of initiatives is given in chapter 2.

Outcomes and success stories, as well as challenges and perceived failings need to be communicated to practitioners, stakeholders and the community. This thesis contributes to this task by examining initiatives across several jurisdictions against a common assessment framework and identifies the common generic structures, practical issues, and outcomes. It draws the information back into a best practice approach and provides a critical strategic assessment of the role and usefulness of indicators as a tool to implement sustainability in the fisheries sector. The research also contributes to the understanding of indicator systems as a generic management tool, and uses a multi-disciplinary method to explore the roles of scientific information and policy instruments to provide integrated decision-making for recognised problems. As stated in *Agenda 21*, without comprehensive scientific information and a policy structure sustainability decision-making is severely impaired.

This thesis differs markedly from the primarily descriptive approaches that have dominated research on indicators to date. It focuses on a critical assessment of indicator initiatives based on comparison across jurisdictions and develops the basis of a best practice systems approach that examines outcomes in relation to sustainability. It is a strategic approach taking the lessons from emerging cases of practice and identifying the challenges, successes and future directions.

Methodology

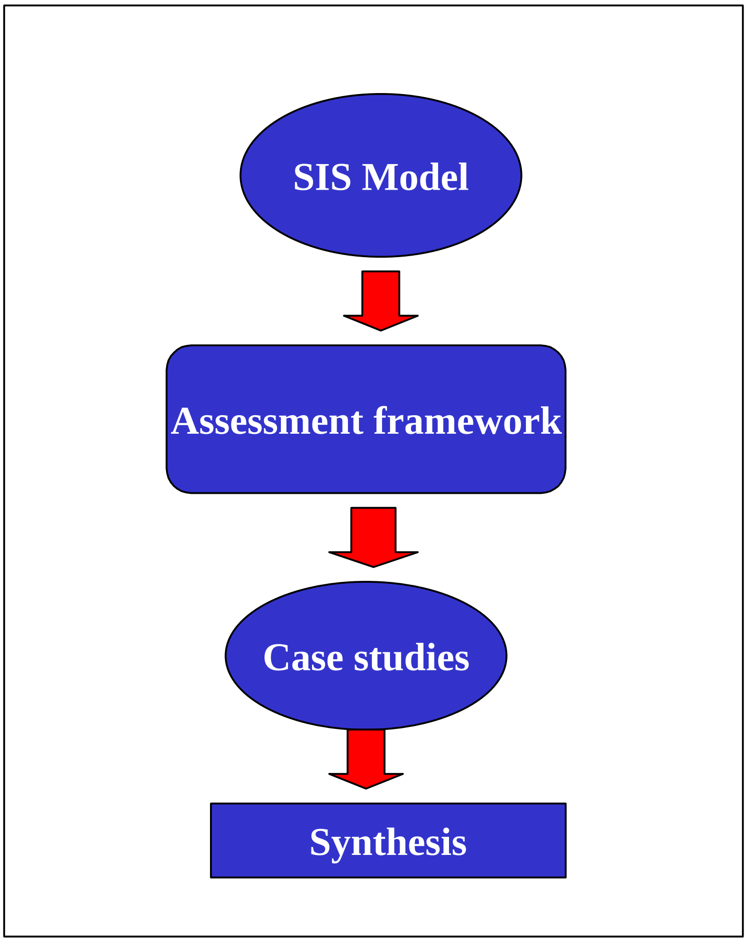
This thesis uses a structured methodological framework to address to the overall aims and objectives. The formal basis of the method lies in the comparative case study approach, highlighted by authors including Hogwood (1984), Devine (1995), Parsons (1995) and Miles (2000). The design of this method focused on addressing the thesis's objectives: identifying the theoretical constructs and components of indicator systems, investigating issues over their application to fisheries case studies, and providing an overall assessment of the role that indicator systems can play in achieving sustainability in the fisheries sector. The use of models is an objective way of highlighting the values, assumptions and processes that influence policy, and subject them to critical analysis. They contribute to an increased understanding of policy issues and can be directly used in improving the process.

This thesis uses a mix of explanatory, ideal-type and normative frameworks in its approach to analyse and assess the use of indicator systems in the fisheries sector. The use of an explanatory model and structured assessment framework is a means to compare case studies. Comparative case studies are useful tools in policy research given the virtual impossibility of using a rigid experimental design in studying the policy process, they allow for the investigation of a variety of issues at appropriate scales from which theories can be tested and insights can be gained. Comparative case studies provide insights into policy related research including (Parsons 1995):

- Analysis of government processes across different jurisdictions;
- Descriptions of the actions of actors in the policy process;
- Information on particular issues or problems; and
- Contribution to the understanding of issues that cross jurisdictions, countries, cultures and sectors.

Four linked key processes form the analytical framework used in this thesis. A basic schematic and description is provided below.

Box 1. Summary of Methods



1. The Sustainability Indicator System (SIS) Model

The SIS model is the foundation of the assessment framework. This conceptual model is used to simplify the elements of indicator systems and to subject them to analysis, identify structures and processes, and set the basis of an indicator system 'standard'. Indicator systems encompass a variety of frameworks, dimensions, criteria, indicators, targets and visualisation strategies. The SIS model represents the generic processes that shape and influence sustainability indicator systems. Based on empirical evidence it focuses on the core indicator system as dependent upon inputs and generating outputs to operate effectively. Inputs involve information to construct the indicators and develop an appropriate structure for the policy need while outputs involve the use and communication of the indicator results in a fashion that improves decision-making.

The SIS model has relied on information from a number of sources. First an extensive review of the literature on sustainability indicators, assessment frameworks and best practice approaches was conducted. This included academic literature, grey literature from national and international sources, research reports, Internet pages, and best practice criteria such as the Bellagio Principles (Bossel 1999). This material was supplemented by discussions with government officials, academics, managers and non-government practitioners working on indicators. This information has fed directly into the SIS model and forms the basis of the assessment framework.

2. The Assessment Framework

The assessment framework forms the basis of identifying and assessing indicator initiatives. It represents the 'lens' through which a range of diverse indicator systems can be assessed. Despite the cases having many similar qualities, each one originates from a unique set of social, economic, geographical and cultural factors. The framework therefore identifies the common reference points or similarities in approaches across the cases. This thesis presents a 'holistic' picture of the state of sustainability reporting across a range of fisheries jurisdictions and highlights the common issues and outcomes.

The framework is composed of a range of criteria or components designed to evaluate several case studies and draws together various issues that face the use of indicator systems in fisheries. These criteria are based on the SIS model described above with additional criteria identified from the literature and information from professionals and sectors. The criteria form the framework for the assessment of SIS in select case studies. The criteria address issues that cover the essential processes and components within indictor systems, 'best practice' concepts and features that are specific to fisheries management.

3. Case Studies

The case studies evaluate the complexities within indicator systems via the assessment framework. (Hyatt 1999) recommends examining a variety of case studies to understand the complexities involved in the development and use of environmental indices, and this approach has been used to investigate fisheries systems. Ten case studies were selected on the basis of an advanced indicator system that had a fisheries component, identified indicators and data, and had available information (see Chapter 3). The cases were also selected on the basis that they demonstrated similar structures as described in the SIS model and would fit the assessment framework. To generate wide coverage, the case studies were selected from national jurisdictions (Australia, Canada and New Zealand), a regional organisation (the Commission for the Conservation of Antarctic Marine Living Resources) and a non-government organisation (Marine Stewardship Council). Australia, New Zealand and Canada all maintain large marine domains – this is a challenge in developing indicators. A common issue between the national case studies was the development of strategic Oceans Policies in each jurisdiction. National, regional and non-government organisations have a role to play in managing fisheries resources and contribute to management in different ways.

4. Synthesis Approaches

On the basis of the assessment framework, the case studies are scored and the results are presented via a series of orientation graphs. Results are displayed for each case study under orientation graphs for each component, and a summary graph. For each case study, the performance of the indicator system can be observed, including specific areas of improvement. To compare the performance of each case study, a series of matrices have been developed to examine the common structures, processes and application issues as identified in the aims.

In addition, to quantitatively rank and visualise the case study results, an experimental tool, the Dashboard of Sustainability was adapted and extended (Jessinghaus 2003). This tool normalises, aggregates and ranks indicator sets, and was adapted to apply to the results of the case studies from the assessment framework. A particular feature of the dashboard is to assign colours to the ranked scores. A seven colour scheme was applied ranging from red for poor performance to green for good performance. The cases can be ranked to according to performance in their individual scores from the assessment framework, or the aggregates of the strategic criteria, including a total aggregate performance based on four strategic criteria. Although caution must be exercised in direct comparison of diverse cases, this approach was deemed useful to examine the range of outcomes and identify 'best practice' systems. The method allows for a visually innovative method of comparing the results from the case studies and facilitates discussion on comparative performance and improvement.

Limitations

Several limitations have been identified from this thesis:

- *The dynamic nature of the topic*. Sustainability indicators and the systems they form a part of, are rapidly gaining acceptance and use in several sectors. As a result, many scientific and policy efforts are underway, with initiatives in a rapid state of transition. This thesis takes a snapshot of several indicator initiatives, effective at September 2003. Several case studies will have significantly progressed after the time of writing.

- *Data limitations*. Indicators are a politically vibrant issue, with many interpretations by stakeholders over their effectiveness and their application. Analysis adopts an objective approach, however subjective decisions were necessary in the 'scoring process' for each case study. In all cases, scoring was consistent with reference to the literature and discussions with experts to determine the result. Each scoring key was referenced against the literature and crosschecked for accuracy.

- *Model limitations*. Models are an interpretation of reality and a way of organising ideas and concepts. They are not reality itself but a process by which we can think and explain (Parsons 1995). The use of various models and frameworks in the study has allowed for the assessment and comparison of indicator initiatives from a variety of jurisdictions, and a series of observations based on the effectiveness of indicators and the issues facing their use. Interpretations of model results need further 'ground-truthing' to verify results and a continual process of review and implementation. Policy models are inherently subjective, and whilst making sense of abstract complex issues, is often only one interpretation of the issue.

Format of Thesis

Chapter 1 examines the notion of sustainability and how it relates to the fisheries sector. It provides an overview of the political history and a brief examination of the major developments in sustainability over the last 20 years. The nature of the fisheries sector is explored with a global overview, major policy developments, examination of the current crisis, and the relevance of sustainability. Chapter 2 examines the use of sustainability indicator systems and indicators as tools to implement and practically apply, measure and assess performance in regards to sustainable development. Basic concepts and theories of indicators are covered, with an examination of several global initiatives and the emerging use of indicators within forestry and fisheries jurisdictions. Chapter 3 focuses on the methodological issues, the SIS model and details the assessment framework and case studies. Chapter 4 describes and assesses select fisheries indicator initiatives from Australia, Chapter 5 initiatives from Canada, and Chapter 6 initiatives from New Zealand. Chapter 7 describes and assesses the regional CCAMLR approach, and Chapter 8 the non-government Marine Stewardship Council initiative. Chapter 9 presents the synthesis of the case study information and directly addresses the thesis aims. Chapter 10 forms the conclusion of the thesis.

Chapter 1: Sustainable Development and Fisheries

1.1 Introduction

The concept of sustainability, and its process driven counterpart, sustainable development, has emerged as a guiding principle and process for all forms of resource development, environmental management and protection, economic development, and social justice. It is a value-laden construct, integrating issues of the environment with issues of development, and exploring the dynamic and reciprocal relationships between the natural world and human society. It has infiltrated all levels of government, sectors of economic and financial activity, non-government organisations (NGOs) and civil society.

The application of sustainability has promoted wide debate and sometimes conflict. Information, or the lack of it, for making decisions on the basis of sustainable development is a real and pressing issue. As a contested concept, the sustainability definition[3] assumes an inherent *flexibility* and contextual application. (Shearman 1990) notes that the principle is often interpreted in sectoral (development, agriculture, fisheries, industry etc) and dimensional (environmental, social, economic) contexts at varying scales (local, national, regional, international and can mean different things to different users.

A core component of sustainability is the assumption that development must meet the ongoing needs of current and future generations. The report *Our Common Future* called for a societal orientation to meet "…the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987). In addition, sustainability implies development occurring within the ecological limits of natural systems in order to maintain their productive capacity (IUCN 1980; Dovers 1990; Shearman 1990). The maintenance of ecosystems in diverse states can provide a variety of goods and services to human interests (Espejo 1998).

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[3] This issue is discussed in detail below. A concrete definition of sustainability can be construed as a disadvantage.

Sustainable development must incorporate an integrated approach that encompasses social, cultural, economic and ecological issues. It is a social construct that addresses the inequalities in the distribution of good and services (WCED 1987; Daly 1995). These objectives are not the only ones considered within sustainable development,[4] but do highlight its ethical basis – that human development and the environment are linked and affect each other.

1.2 The International Progression of Sustainable Development

The progress of sustainable development on the international stage can be tracked with the passage of several binding and non-binding policy instruments. Several international forums have grappled with a definition and considered integrated economic, social and environmental issues for global environmental problems. As a result, sustainability has evolved as a concept that highlights the transboundary nature of environment-development issues. The instruments described below represent milestones for the development of the concept at an international level and contribute to the implementation of sustainability at the national, sub-national and local levels.

1.2.1 Pre-UN Conference on Environment and Development 1992.

The 1972 UN Conference on the Human Environment represented an evolution of the rules for environmental protection and the foundation of the notion of sustainable development. Attended by 113 states, the conference resulted in a Declaration and Action Plan that defined principles for the preservation and enhancement of the natural environment, and the central role of human society (Gardiner 2002). The Conference led to the formation of the UN Environment Program (UNEP). The conference and declaration raised awareness of sustainability by highlighting the integrated nature of environmental and socio-economic issues on the international stage (Birnie 1995). (Herriman 1997) notes that the Declaration played an important role in the process of creating and contributing to important future governance instruments such as the United Nations Law of the Sea Convention (LOSC).

In 1980 the World Conservation Strategy was published by international NGOs and sponsored by United Nations Food and Agriculture Organization –FAO- and the United Nations

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[4] Many authors have explored the concept of sustainability and attempted to define its core components. Further detail can be found in WCED 1987; Shearman 1990; Daly & Erlich 1995; Hodge 1995; Vojnovic 1995; Espejo 1998; Bell & Morse 1999; Rhydin 1999; and Dovers 2000.

Educational Scientific and Cultural Organisation – UNESCO - (IUCN 1980). The strategy stressed the integrated nature of conservation and development (Jones et al 1990) and built upon the idea of sustainable development presented in the Stockholm Declaration. It identified the base causes of environmental degradation as poverty, population pressure, social inequity, and the terms of trade (IUCN 1980). The World Conservation Strategy called for a new 'development ethic' that readdresses inequities, and creates stable economies that stimulate growth and counteract poverty (IISD 1999).

The World Conservation Strategy identified three concepts fundamental to the ecological tier of sustainable development (IUCN 1980):

- That species and populations, whether plant or animal, must be helped to retain their capacity for self renewal;
- That the basic life support systems of the planet, including climate, the water cycle, and soils must be conserved intact if life is to continue.
- That genetic diversity is a major key to the future well-being of the earth and must be maintained.

The World Commission on Environment and Development (WCED) and its influential report *Our Common Future* was established following the UN General Assembly Resolution adopted at the 38th Session of the United Nations in 1985 (WCED 1987). The independent Commission was convened to:

- To re-examine issues of environment and development;
- To strengthen international cooperation on the environment and development;
- To raise the level and understanding and commitment to action on the part of individuals, voluntary organisations, businesses, institutes and governments.

The WCED was established at a time when concern over issues of environment and development were on the rise. There was a need for debate about the ideological concept of sustainability and investigation of global environmental problems related to economic development. The key issues the Commission would investigate were (WCED 1987):

- Perspectives on Population, Environment and Sustainable Development;
- Energy: Environment and Development;
- Industry: Environment and Development;

- Food Security, Agriculture, Forestry, Environment and Development;
- Human Settlements: Environment and Development;
- International Economic Relations, Environment, and Development.
- Decision Support Systems for Environmental Management; and
- International Cooperation.

Our Common Future opened the debate on sustainability and acted as catalyst for a number of international and national initiatives (Slater 1991; Commonwealth of Australia 1992; Goodlund 1993; IISD 1999). The WCED defined sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987). It includes the notion of environmental protection and economic growth to meet the needs of the present population, and the maintenance of resources for future generations (Upreti 1994). The definition leaves great room for debate, and since its inception it has attracted constant review, criticism and refinement – exactly what it set out to achieve.

1.2.2 The UN Conference on Environment and Development (UNCED)

UNCED was held in 1992, twenty years after the Stockholm Declaration. It was a major turning point in global recognition of sustainable development with an adopted Declaration and a global program of action, Agenda 21 (UNDSD 2002b; Gardiner 2002). The UN Resolution that established the conference (Resolution 44/228) stated that it aimed to "further the development of international law and examine the feasibility of elaborating general rights and obligations of states in the field of the environment… "(Birnie 1995). UNCED provided a forum for governments and non-governmental organisations to come together and address the major environmental and developmental issues of the day. The results from this conference have been far-reaching and influential in policy formation at all levels (Herriman 1997; IISD 1999). A major output was the creation of the UN Commission on Sustainable Development (UNCSD 2002a) and the action document, *Agenda 21*.

Agenda 21, or the Agenda for the 21st century, was adopted at the UNCED plenary in June 1992 (United Nations 1993). It was an influential policy that represented a step forward for the international community in the evolving debate on sustainability (Commonwealth of Australia 1992). Agenda 21 provides a comprehensive plan covering a broad range of environment and development issues with specific directives on how to progress toward integrated outcomes. The document was adopted by consensus from 176 States at UNCED and provides a plan to which governments and organisations can take to achieve patterns of development that are within sustainable limits (Harden-Jones 1994).

Agenda 21 is divided into four main sections, they include (United Nations 1993):

- **Social and Economic Dimensions** – Address key economic and human factors such as trade, debt and population issues and national decision making processes leading to sustainable development.
- **Conservation and Management of Resources for Development** – Addresses the full range of environmental resources and ecosystems (e.g. Chapter 17 on Oceans), and objectives to be achieved at global, regional, national and local levels.
- **Strengthening the Role of Major Groups** – Investigate the role of community, representative and industry organisations in policy formation.
- **Means of Implementation** – Looks at the resources which must be harnessed in support of sustainable futures, including finance, technology, education, institutional and legal structures, and data.

Agenda 21 called on governments to adopt national strategies for sustainable development in collaboration with non-government organisations, business and the public. (United Nations 1993; UNCSD 2002b). Governments were directed to work in partnership to achieve negotiated outcomes on a variety of issues that are central to sustainable development.

Whether the goals of *Agenda 21* have been achieved remain an object of debate. This ranges from a lack of integration in national decision-making to a lack of clear objectives for management (Frazier 1997; Wijkman 1999). To achieve the objectives set by Agenda 21, political commitment, practical action and binding targets are required by nations and organisations.

At the Rio Earth Summit 1992 two other important instruments were formed as outcomes from the conference. The Convention on Biological Diversity 1992[5] and the Framework Convention on Climate Change 1992[6] represent significant international negotiations that attempt to resolve environmental issues of a global nature, and were major international environmental policy decisions that have shaped the face of international environmental law. In addition the summit produced the Commission for Sustainable Development (CSD) and many countries set up commissions and/or national strategies for implementing sustainable development.

1.2.3 Post UN Conference on Environment and Development

UNCED was a major step in fostering international collaboration and negotiation on issues of sustainable development with Agenda 21 establishing the framework for cooperation by national governments, NGOs and private organisations. Despite influencing policy, it has avoided setting binding targets – it is a guide for action, not a binding instrument, and therefore requires political will and negotiation to succeed.

The World Summit on Sustainable Development (WSSD), commonly known as Rio +10, was held in Johannesburg, South Africa in 2002. It presented an approach to re-examine the issues surrounding the implementation of Agenda 21. One hundred world leaders addressed the Summit, with more than 22,000 people participating, including more than 10,000 delegates, 8,000 NGOs and representatives of civil society, and 4,000 members of the press (United Nations 2002a;). The WSSD embarked on a series of preparatory meetings, aimed at highlighting the critical issues surrounding *Agenda 21* implementation and progress towards sustainability (United Nations 2002b; United Nations 2002c). The WSSD resulted in a new Declaration and action plan, the Johannesburg Plan of Implementation, that reaffirmed the international commitment to the goal of sustainability. Article 5 of the Declaration states (United Nations 2002d):

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[5] The Convention on Biological Diversity was signed in Rio in 1992 and entered into force in December 1993 (CIESIN, 1998). Its objectives are: "the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding."

[6] The United Nations Framework Convention on Climate Change was signed in May 1992 and entered into force in 1994 (CIESIN 1998). The Convention was negotiated and signed by 165 states (Secretariat, 1999) to negotiate solutions to human induced climatic change (Herriman *et al* 1997). The Convention allowed States to recognize the problem and construct a platform for dialogue on limits, and collaboration

> *Accordingly, we assume a collective responsibility to advance and strengthen the interdependent and mutually reinforcing pillars of sustainable development – economic development, social development and environmental protection – at local, national, regional and global levels.*

The WSSD Plan of Implementation (United Nations 2002d) is designed to further commit nations to a series of agreements, objectives and targets for the implementation of Agenda 21. Critics have argued that the plan does not go far enough to securing concrete outcomes (Anon 2002; WWF 2002) but it does make significant commitments in several key areas including oceans, energy and sanitation issues (United Nations 2002a; United Nations 2002c). The Summit also focused on the development of voluntary partnerships with the launch of more than 300 initiatives (United Nations 2002c). In addition, formal dialogue occurred between governments, civil society and the private sector on partnerships and funding (United Nations 2002c). Whether political commitment to sustainability will be enhanced and translated into government action remains to be seen. The rise in partnerships and initiatives from other stakeholders is a progressive development that should encourage governments to commit to action.

1.3 Conceptualising sustainable development

Despite wide recognition, the practical implementation of sustainability remains a significant hurdle. This translates to an inherent difficulty with measurement and application, as identified in Chapter 40 of Agenda 21. The strength of the concept lies in its integrative nature that brings diverse interests together to negotiate common outcomes, despite the inherent difficulty of a consensual definition.

1.3.1 Problems with definition

The term ‘sustainable development’ has endured a long debate over its definition (Shearman 1990; Bell & Morse 1999; Rhydin 1999). Wide interpretation has resulted in a measure of support in principle if not in practice. As the term contains references to environmental protection and conservation, social justice and equity, and economic reform it attracts a broad base of support sectors. O'Riordian (1998; 15) notes the term is a:

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in data collection and research. Several states have been slow to act or have adopted airs of self-interest in negotiations for pollution limits, for example in the recent Kyoto round of agreements.

> *Metafix that will unite everybody from the profit minded industrialist and risk minimising subsistence farmer to the equity seeking social worker, the pollution concerned or wildlife loving First Worlder, the growth maximising policy maker, the goal orientated bureaucrat and the vote counting politician.*

The current institutional definitions are sweeping statements that contain a mix of concepts such as generational equity, social cohesion, economic benefits, efficiency, conservation and environmental protection (Buckley 1991; Dovers 1990; Frazier 1997; O'Riordian 1998; Lumley 1999). A number of prominent international definitions are provided below in Box 1. Several commentators observe that 'official' definitions of sustainable development are too vague and inoperable to apply to individual projects or programs (Dahl 1995; Meadows 1998). Sustainability must be interpreted into the context of the issue to remain effective (Hodge 1995; Moldan 1997).

Box 2 . International definitions of sustainable development.

World Conservation Strategy (IUCN 1980; 2):

> *For development to be sustainable it must take account of social and ecological factors, as well as economic ones, of the living and non-living resource base, and of the long term as well as short-term advantages and disadvantages of alternative actions.*

Our Common Future (WCED 1987; 43):

> *Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts; (1) the concept of 'needs', in particular the essential needs of the worlds poor, to which overriding priority should be given; and (2) the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet future and present needs.*

The National Strategy for Ecologically Sustainable Development (Commonwealth of Australia 1992; 2):

> *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.*

Food and Agriculture Organisation of the UN (FAO 1989; 4):

> *Sustainable Development is the management and conservation of the natural resource base, and the orientation of technological and institutional changes in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development conserves land, water, plant, and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable.*

The generalisation of sustainability has rallied many parties to agree with its aims, a process not to be underestimated. It has brought together nations and organisations from around the world and from a variety of disciplines to agree and negotiate on matters on environment and development, to agree on a common goal for human interests, generate policy and to recognise that environmental problems are global in scope and require a combined response. The generalist notion has been ratified into domestic policy and legal regimes, and continues to influence existing domestic and international environmental programs (Commonwealth of Australia 1992; Birnie 1995; CIESIN 2003). O'Riordian (1998) comments that the institutional response to sustainable development, while slow and still requiring political leadership and change, has resulted in the development of a variety of monitoring regimes, regulatory requirements, environmental assessment methods, public awareness, and the politicising of environmental issues. The challenges of implementation still lie ahead, but as O’Riodian (1998) observes, society is in the early stages of a ‘sustainability transition.’

1.3.2 Applying the generalist approach

Shearman (1990) presents the case that the meaning of sustainability is far from ambiguous. He argues that the formal meaning is the ‘capability to be maintained’ or ‘continuity through time’ and that this meaning is well understood in institutions and sectors. The ambiguities result not from the term itself but from the application of sustainability as applied to a particular context. Shearman (1990; 1) notes:

> *Instead of trying to come to terms with some ambiguous meaning of sustainability as it is set in various and conceptually distinct contexts, our task becomes one of ascertaining the implications of a commonly understood notion of sustainability as applied to these various contexts.*

This argument is of considerable merit. The general definitions of sustainability put forward by international and national institutions are readily understood as general principles and desirable outcomes. The examples in Box 1 clearly display this, the definitions making broad, sweeping, generic statements that detail desirable outcomes. The difficultly rises from the application of these principles to interacting sectors, governmental processes and a variety of stakeholder interests. It is important to note that this ambiguity is one of process and application rather than definition. It is undesirable from a practical policy viewpoint to seek a rigid and inflexible definition of sustainability. By doing so denies a core aspect – adaptability (Meadows 1998; Bossel 1999). Sustainability is not a fixed state and needs to adapt to, and be adapted by, the context in which it is situated. To develop policy measures and systems of measurement, sustainability must be interpreted from the basis of an agreed consensual definition to a specific and contextual application (Dovers 1990; Buckley 1991; Groups 1991; Moldan 1997; Bell & Morse 1999; Bossel 1999).

Figure 1 demonstrates this hierarchical approach with the examples of health and sustainability as societal goals. A strategic objective of sustainable development is healthy and well-managed fisheries. This further translates (but is not limited to) to the operational objectives of stock conservation, ecosystem protection and economic viability. Specific actions are identified to achieve these objectives that include research and monitoring, ecosystem mapping, protected areas, managing by-catch and addressing harmful subsidies. Therefore sustainability is conceptualised as a hierarchical approach with action plans guided by and nested within operational objectives, and operational objectives nested within broader strategic goals based on the societal level objectives. Using a hierarchical approach provide the basis for implementing practical outcomes and assessing performance.

Figure 1. The 'trickle down' approach to conceptualising societal goals.

Societal Goals	**Health**	**Sustainable Development**
Strategic Policy Objectives	Universal medical access, healthy population	Sustainable and healthy fisheries
Operational Objectives	Create and maintain universal health care system	Conserve stocks Implement ecosystem management Economic viability
Actions	Legislation Funding Infrastructure	Improved research and stock assessment. Ecosystem mapping and protection, by-catch reduction, risk assessment. Reduce subsidies,

Adapted from (Dovers 1990).

1.4 Sustainability of Marine Capture Fisheries

1.4.1 A History of Global Fisheries

Prior to the 19th century, scholars viewed the oceans as a vast frontier with inexhaustible resources, creating the philosophy of the freedom of humanity to exploit the seas [7] (Friedheim 1999; Smith 2000). The concept of overfishing was non-existent, as the dominant worldview was one of unlimited resources and a massive ocean frontier. With limited local capacity to fish, marine productivity was far in excess of catching capacity (Haggan 1998; Smith 2000).

The 19th century saw an expansion of the global fleet and the development of distant water capacity (Smith 2000). Advances in the industrial revolution increased the capability of vessels to access distant fishing grounds and to catch fish through developments in gear. The development of the steam engine, refrigeration, the auction system, and road and rail transport facilitated the rapid development of the fishing industry, new markets, and increased production (Smith 2000; Garcia 2001; Kaye 2001). External investment was an influence in the search for new grounds and capacity investment – bigger boats, better gear, improved market connections, and increased demand for marine products.

In the late 19th century, the idea emerged that intense harvesting of marine resources could detrimentally affect populations (Friedheim 1999; Kaye 2001). Sealing and whaling expeditions in a short period had depleted many localised populations in the South Georgia region of Antarctica [8](Walton 1987). Questions were being asked about the nature of the fishery resource and its capacity to support increased industry development.[9] Concerns were expressed at an international level about the conservation of fish stocks in the North Sea in 1881 and led to a major conference at that time [10](Kaye 2001). At the turn of the century, conservation issues and increased speculation about the nature of fishery resources led to the development of the

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[7] Scholars such as Grotius in his essay Mare Liberum (Grotius 1604) expressed the notion that the seas were vast and inexhaustible and ‘not capable of possession’. Several authors refer to the ‘Grotian notion’, i.e. the freedom of the seas and the right of ocean users to do as they please as long as the rights of others are not violated.
[8] During the period 1801-1822 over 1 200 000 skins were taken from South Georgia. In 1819 the South Shetlands were opened up and the industry had depleted numbers in 2 seasons. Expeditions in the 1870’s could only find 1450, 600 and 110 seals in consecutive seasons (Walton 1987).
[9] Caird *et al* (1866) presented a report to the British Parliament questioning the nature and capacity of fish stocks as a source of protein for the British Empire.
[10] Several North Sea powers attended the conference that was concerned with the enforcement and policing of fisheries.

International Council for the Exploration of the Sea (ICES) which aimed to "promote and encourage research and investigations for the study of the sea, in particular those living resources thereof " [11] (CIESIN 1998). This was an important development for international fisheries management as a scientific organisation was influencing the development of management measures. ICES provided technical information and advice for a number of agreements and set the role for similar relationships between scientific institutions and governments in the future (Botsford 1997; Kaye 2001). It was in the later half of the 19th century that saw the science of fisheries biology mature and develop theories on population dynamics (Harden-Jones 1994). This led to the development of theoretical models to assess the status and populations of stocks with research providing the life history information for the models [12] (Harden-Jones, 1994).

The 20th century was an era of immense change in the management of marine resources. During the first and second world wars fishing activity slowed, but post World War II activity saw the start of an age of expansionism with intensification of industrialised fisheries in coastal regions (Smith 2000). After the Second World War countries began to focus on the development of capacity to re-establish food production (Garcia 1996). From the 1950s to the 1970s industrialised fleets were discovering new grounds and using new technologies that enabled them to sail further and fish longer and deeper. The FAO reports that in 1950 less than 20 million tonnes had been extracted from capture fisheries and by 1970 the amount had trebled to 60 million tonnes (FAO 2000).

Signs of stress were beginning to appear in several large-scale fisheries during the 1960s and 1970s (Hannesson 1995). The Atlantic herring fishery was important for many north Atlantic nations. In Icelandic waters alone 400,000 to 600,000 tonnes per year were being caught by nationals and distant water fleets (WWF 1998). The fishery collapsed in 1967. In 1971-1972 the Peruvian anchovy fishery off the coasts of Peru and Chile collapsed with global repercussions. Overfishing was a significant factor in the collapse (Pauly et al 2002). In addition, North Atlantic demersal fisheries such as haddock, halibut and cod were showing signs of depletion (Fairlie 1995; Botsford 1997; Haggan 1998). Fishing pressure and high levels of effort continued regardless despite the signals from the stock, and as a result the cod stocks off New England and eastern Canada collapsed in the early 1990s with dire regional socio-economic consequences (Buckworth 1998; Charles 1998; Pauly et al 2002).

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[11] The Convention for the International Council for the Exploration of the Sea was created in 1964, formalising the 'gentleman's agreement' from 1902.

The spread of distant water fleets, the increase of capacity and the stress signals in stocks gave rise to a conflict between coastal states and nations that had invested in distant water fleets (WWF 1998; Smith 2000). It had become obvious that fisheries resources were not inexhaustible and could collapse under intense pressure. The response from coastal states when these resources were under threat was to stake a claim and enclose these fishing grounds to protect them from the foreign fleets (Friedheim 1999).[13] The distant water fishing nations that adhered to the 'freedom of the seas' paradigm protested that coastal states could not claim jurisdiction over resources that were not legally theirs (Kaye 2001). A well-known example were the 'Cod Wars' that occurred between Iceland and Britain when Iceland extended its maritime jurisdiction in an attempt to control the fisheries resources (WWF 1998). The USA in 1945 proclaimed jurisdiction over areas of continental shelf that was followed in later years by claims from Latin American countries (Garcia 2000). These conflicts and declarations set the stage for 50 years of negotiations over territorial use rights and marine resources (Opeskin 1997; Garcia 2000).

Fisheries in the 20th century have shifted from local activities to global market-influenced industries employing millions and generating export income for many nations. It is essential to understand that despite this growth, local communities still depend on fisheries resources as a source of protein and livelihood. Small-scale community fisheries employ 50 of the worlds 51 million fishers, most from developing countries (Berkes et al 2001). Coastal marine and freshwater resources are under stress, with many showing signs of resource degradation and collapse as a result of increasing fisheries exploitation and habitat degradation (Buckworth 1998). The geographical spread and intensification of fisheries around the world is continuing, as is the demand for products by a growing population and market economy.

1.4.2 The Present Situation in Global Fisheries

In the 21st century new pressures are emerging on global fisheries. Fishing is a global market-driven industry that employs and supports millions of people, it is a means of earning foreign currency and investment and, most importantly, a source of food for a growing population (Emerson 1995; Stone 1997). Coastal States have embraced economic opportunities by investing in fleets and processing factories in response to the growing international demand for fisheries products (Mfodwo 1998). Developing nations are increasingly reliant upon fishery resources,

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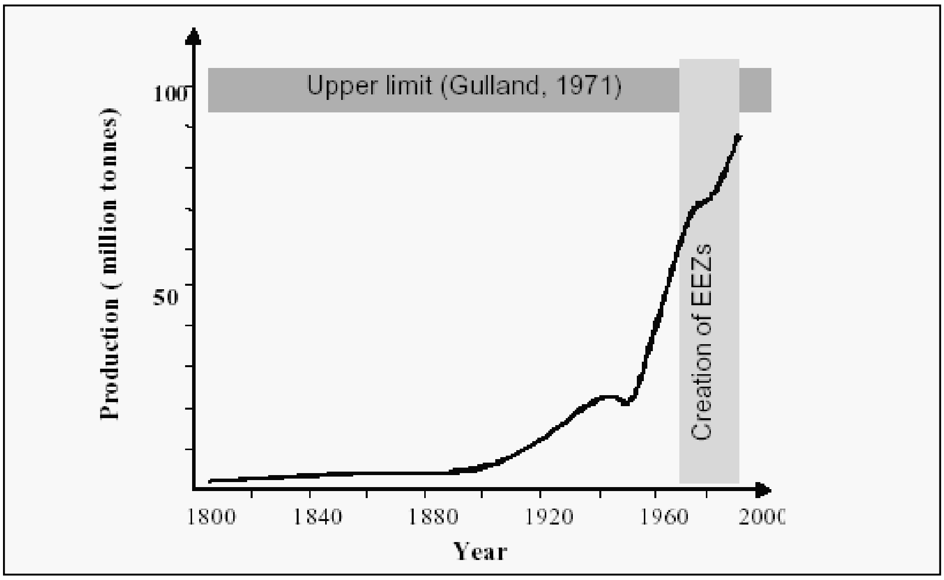
[12] Catch statistics included catch and data, and biological data such as biomass estimates, recruitment, growth rates, reproduction rates and the rate of mortality (Harden-Jones 1994 & Iversen 1996).

with the catch doubling from 35% to 70 % between 1960 and 1994 (Buckworth 1998). Increasing encouragement is placed upon developing nations to modernise their operations and to increase the standard of living and earn foreign exchange (Fairlie 1995).

Fisheries production has risen exponentially over the last century (Figure 2). In the middle of 19th century, the world fish catch was two million tones (Buckworth 1998). The FAO notes that in 1900 global catch was approximately 5 million tonnes and expanded to 18 million tonnes in 1950 (FAO 2000). Capture rose at an average of 6% per year to 56 million tonnes in 1969 (FAO 2000; Garcia 2001). During the 1970s and 1980s the increase declined to 2 percent per year, and has fallen to almost zero in the 1990s (FAO 2000).

Figure 2. Trends in world fisheries production during the last two centuries.



Adapted from (Garcia 2001).

Table 1 details the production of marine and freshwater fisheries systems. The total world production of fisheries products in 1999 was 125 million tonnes. Of this amount, 33 million tonnes was from aquaculture and 92.3 million tonnes from marine and freshwater capture fisheries. Marine capture fisheries comprise over 90% of the capture total with 84 million tonnes. The figures indicate that in 1998 marine capture fisheries experienced a significant decline. FAO claims that this is due to climate anomalies such as El Nino affecting marine stocks (FAO 2000).

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[13] More information on the on the freedom of the seas and early maritime jurisdiction can be found in Emerson 1995; De Fontaubert 1998; Friedheim 1999; and Smith 2000.

Table 1. World Fisheries Production in millions of tonnes.

Production	1995	1996	1997	1998	1999	2000	2001
INLAND							
Capture	7.2	7.4	7.5	8.0	8.2	8.8	8.8
Aquaculture	14.1	16.0	17.6	18.7	19.8	21.4	22.4
Total Inland	21.4	23.4	25.1	26.7	28.0	30.2	31.2
MARINE							
Capture	84.3	86.0	86.1	78.3	84.1	86	82.5
Aquaculture	10.5	10.9	11.2	12.1	13.1	14.2	15.1
Total Marine	94.8	96.9	97.3	90.4	97.2	100.2	97.6
Total Capture	91.6	93.5	93.6	86.3	92.3	96.7	99.4
Total Aquaculture	24.6	26.8	28.8	30.9	32.9	33.7	29.4
Total World	116.1	120.3	122.4	117.2	125.2	130.4	128.8

Adapted from (FAO 2002).

Increase in total production over the 1990s has been predominantly from a constant increase in aquaculture production. From 1995 to 2001 there was an estimated rise in production from 24.6 to 29.4 million tonnes from this sector. The bulk of the capture fisheries, from marine sources, have fluctuated between 82 and 86 million tonnes, with a sharp decline in 1998. From these figures it can be interpreted that the global marine captures have reached their maximum potential for production. This is evidenced by the landings data over the last 50 years with strong production through the 1960s to the 1980's slowing substantially during the 1990s (Buckworth 1998).[14] Further evidence to suggest that the world fishery is nearing its sustainable limit comes from the often-quoted figure that approximately 70% of stocks, for which data is available, are fully exploited, recovering or depleted (Garcia 1996; Caddy 1999; FAO 2000). The erosion of individual stocks, which at ecologically stable levels provide a renewable resource, reduces the potential of fisheries to maintain global catches. Garcia (1996) notes that the *per capita* supply of

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[14] Recent evidence cited by (FAO 2002 & Pauly *et al* 2002) suggest that over reporting and inflation of catches by the Peoples Republic of China has led to the masking the true trajectory of global fish catches.

fisheries products has declined with a growing human population. The information confirms estimates made by FAO in the early 1970s that the global potential for marine fisheries is approximately 100 million tones (Garcia 2001).

The stresses on stocks are possibly underrated with several authors noting that bycatch is not reported in landing figures[15]. (Buckworth 1998) estimates that in 1992, between 17.9 and 39.5 million tonnes of marine species were taken as bycatch and discarded. The FAO reports on the revision of these statistics, an estimated 20 million tonnes per year, or a quarter of the total marine capture that is discarded and not reported (FAO 1998). Many recreational fisheries and subsistence fisheries are not included in these figures. In addition misreporting from Illegal, Unregulated and Unreported (IUU) fishing[16], undeclared catches and imprecise estimations can form up to 20-30% of the recorded total (Garcia 1996; FAO 2002).

With a high proportion of stocks at fully exploited levels, current estimates of production approaching a maximum yield, and significant underreporting from bycatch and IUU fishing, an emerging crisis is apparent in global fisheries. Pauly et al (2002) has observed a global decline of trophic levels in global landings. The paper describes the gradual removal of large predatory long-lived fish from the world's oceans with serious ecological repercussions. Within the industry, there is pressure for fisheries to increase or at least maintain levels of production. Existing global overcapacity serves to place pressure on fisheries in the present, while the need to provide protein for a growing human population[17], earning foreign capital[18] and maintaining livelihoods will place pressure on fisheries in the future. Solutions and innovative management is required for global fisheries to provide benefits for human populations now and in the future within healthy functional marine ecosystems.

1.4.3 Challenges in the 21st Century.

Correcting for this showed that reported world fisheries landings have in fact been declining slowly since the late 1980s.

[15] This was noted by Alverston *et al* 1994; Botsford 1997; Buckworth 1998; Fisheries 1999; FAO 2000; and FAO 2002.

[16] There is a serious commitment to developing a comprehensive picture of the IUU fishing issue. It has been claimed that IUU fishing can be as high as three times the permitted catch level (FAO 2002).

[17] The human population reached 2.5 billion in 1960, 4.5 billion in 1980 and 5.7 billion in 1995. The low median United Nations projection for 2015 is 7.3 billion and it is estimated to rise further (Friedheim 1999). Buckworth (1998) estimates that food fish deficit will grow as the demand for food increases with the population, a further 65 million tonnes required by 2025.

[18] There will be an acute pressure from developing nations as they increase fishing capacity and product exports in a global economy.

Global statistics and future projections, combined with comments from experienced authors, suggest that a crisis is looming[19]. (Lane 1999) suggests that the 'modern fisheries experiment' of the past four decades has failed in its objectives and has resulted in a crisis, driven by environmental degradation from long-term overuse and severe global overcapacity. In response, the last twenty years has seen a radical change in the philosophy of management, scientific approach and the legal/policy regime behind global fisheries management. With the advent of the 'crisis' so have appeared new solutions and ideas to resolve the issues. Since the negotiation of Law of the Sea Convention (LOSC) there has been a gradual extension of waters under national jurisdiction and enclosure of ocean space (Garcia 2000; Yuile 2000). This has resulted in a highly fragmented system of oceanic domains with 90% of fisheries resources under a form of national jurisdiction, and 10% (and a large proportion of the ocean area) left in the high seas. The negotiation of the LOSC provided not only a global framework with which to manage marine resources and regulate ocean activities but also the realisation that global fisheries problems required a negotiated response (Garcia 2000). As a result, there has been the establishment of a complex regime of legal instruments that attempt to address many of the problems in international fisheries. These instruments will be expanded upon below.

1.5 The Development of International Instruments for Fisheries Sustainability

A wide range of instruments has been negotiated for the management of marine resources beginning with the signing of the UN Law of the Sea Convention in 1982. Kaye (2001) identifies that an entire new sub-regime has been established specifically for fisheries management. Consequently a number of instruments have been developed with the specific purpose of regulating how fishing is carried out while other instruments have focused on broader conservation issues. These range from 'soft law' instruments that are not legally binding but have political and moral force and 'hard law' instruments that are binding on signatories (Tsamenyi & McIllgorm 1996). Both sets of instruments form the mosaic under which international fisheries are managed and provide objectives and actions for national systems. A brief chronology of relevant international instruments is provided below.

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[19] See Sharp 1996; Botsford 1997; Buckworth 1998; Hagan 1998; Fowler 1999; Kay and Hughes 2000; and Smith 2000.

1.5.1 The United Nations Convention on the Law of the Sea 1982 (LOSC)

The LOSC has been dubbed the ‘constitution for the oceans’.[20] The convention is a framework regime for all aspects of ocean sovereignty, jurisdiction, use, rights and obligations including the management of fisheries (Tsamenyi & McIllgorm 1996; Weeber 1998). It aims to balance competing interests from different uses of the sea and to do so in a way that minimises conflict in the international community (Opeskin 1997). Its approach to resolve important jurisdictional questions has been to identify who is responsible or has the right to make decisions relating to important aspects of ocean use (Garcia 2000). The obligations of states are found in the LOSC while the legal rights and obligations of those responsible for managing fisheries are prescribed in the national system of law (Kaye 2001). This adds credence to the fact that it is a ‘framework’ document, as it states the basic objectives and structure of ocean management but leaves the actual procedures to States and management authorities.

The convention arose out of 50 years of discussions and three conferences. The Third UN Conference on the Law of the Sea was convened in 1973 and met in 11 sessions until 1982, when agreement was made on the text of the convention. The treaty spans some 320 articles and nine annexes and has been hailed as an achievement in multilateral treaty making (Opeskin 1997; Friedheim 1999).

LOSC divides up most of the ocean area between zones wherein the coastal states have exclusive jurisdictional rights (Figure 3)(Garcia 2000). The convention identifies and delimits the maritime zones shown above and specifies the rights and duties of states within those zones. Important zones include the territorial sea, contiguous zone, exclusive economic zone, continental shelf, and the high seas [21]. Generally the rights of a coastal state diminish as one moves away from the coastline (Opeskin 1997). One of the most important delimitations in terms of marine resources was the Exclusive Economic Zone (EEZ). The EEZ extends 200 nautical miles from the baseline with the coastal state maintaining sovereign rights over living and non-living resources (Fisher 1996; Opeskin 1997). In addition, claims can be made that extend sovereign rights to non-living resources on the continental shelf that lies outside the 200nm zone (Vidas 2000; Green 2001).

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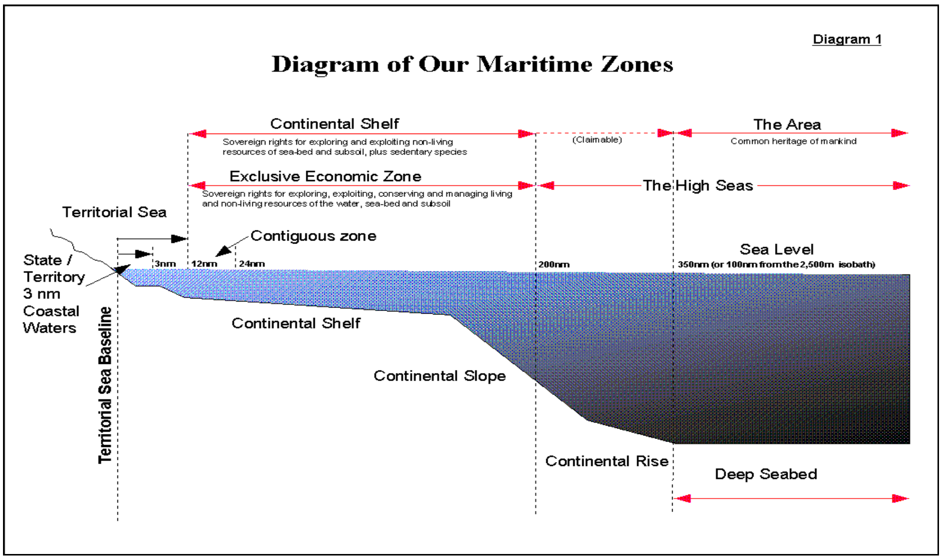
[20] For detailed descriptions of LOSC refer to Birnie 1995; Fisher 1996 ; Opeskin 1997 ; De Fontaubert 1998; Friedheim 1999; and Kaye 2001.

[21] For a detailed description of each zone refer to Garcia & Hayashi 2000 & Tsamenyi & McIllgorm 1996.

Figure 3. Maritime Zones. And Jurisdictions



Adapted from (Commonwealth of Commonwealth of Australia 1998aa).

The rights of a coastal state in the EEZ are set out in Article 56 of the Convention, namely for 'sovereign rights for the purpose of exploring, exploiting, conserving and managing natural resources, whether living or non living, of the waters super adjacent to the seabed and of the seabed and subsoil' (Herriman et al 1997). Articles 61 and 62 set out the rules for management of fishery resources within the EEZ [22] (Tsamenyi & McIllgorm 1996; Herriman et al 1997). Coastal states determine on the best scientific basis, the total allowable catch of the living resources in the EEZ. In determining the catch of living resources, states are obliged to ensure through proper conservation and management measures that such resources are not over-exploited (Article 61). In addition the state must consider species that are associated with or dependent on harvested species with a view to maintaining their populations above threatened levels (Article 61[4]) (Herriman et al 1997).

The increased power available for states to regulate activity within the EEZ has resulted in greater exploitation of resources on the high seas, particularly by distant water fishing nations (Hannesson 1995; Fisher 1996; Stokes 1999). The high seas are classed as the area of ocean that lies beyond the jurisdiction of coastal states, that is, all parts of the sea that is not included in internal waters, territorial sea, EEZ or archipelagic waters (Emerson 1995). The management of the high seas is subject to a less detailed regulatory regime (Stokes 1999). The particular

[22] For a detailed description of the legal responsibilities of harvesting of fishery resources in the EEZ refer to Fisher 1996.

jurisdictional feature of the high seas is that they remain open to all states under what is termed the ‘freedom of high seas’ (Article 87). Included in these rights is the freedom to fish on the high seas (Article 116). In an attempt to avoid overexploitation the LOSC states in Article 117 and 118 that states are under a duty to take necessary measures for the conservation of living resources on the high seas and to cooperate with other states in taking measures to conserve living resources (Stokes 1999; Kaye 2001). The regime for high seas management has been noted to contribute to the overexploitation of marine resources (Emerson 1995; Schram 1995; Yuile 2000). A lack of regulatory detail for the duties of states engaged in fishing and the notion of the ‘freedom’ to fish on the high seas has resulted in a lack of incentive to conserve resources and generate minimal cooperation between states (Emerson 1995; Hannesson 1995; Stokes 1999).

UNCLOS created the climate and framework to address core problems of resource degradation in the oceans through the process of ocean enclosure, establishing ownership and clarifying decision-making (Garcia 2000; Smith 2000). Open access systems are inherently subject to overexploitation due to a lack of incentive to conserve while a system that is ‘owned’ is much less likely to be abused [23] As noted in Friedheim (1999) and Hall (1998) clarifying ‘who’ is an important step for avoiding overexploitation, however the structure and operation of the management regime is critical to determine success - the ‘devil is in the details’.

After the adoption of UNCLOS many countries pushed the development of domestic fisheries and experimented with management regimes (Garcia 1996). As a result, there was an increase of fishing pressure on stocks under national jurisdiction, and as distant water fleets were displaced, a corresponding rise in pressure on high seas fisheries (WWF 1998). Institutions such as the FAO recognised this increase in pressure and the threat to the sustainable utilisation of stocks. The International Conference on Responsible Fishing, held in 1992 in Cancun, Mexico, was requested to prepare an international Code of Conduct to address these issues. An outcome of the conference, the Declaration of Cancun, was a document that identified issues of critical importance [24] and formed an important precursor to the 1992 United Nations Conference on Environment and Development.

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[23] The pivotal debate provided by Hardin in his essay ‘The Tragedy of the Commons’ set the basis for the issues surrounding open access resource use (Hardin 1968). Resources held in common were deemed to be subject to abuse because there were no incentives to conserve the resource. If an area or resource would come under some form of ownership, a managed commons, the incentive to conserve would be greater due to social rules or norms that constrain overexploitation. Hardin’s argument contains merit, but tends to oversimplify the problem. For further discussion refer to Feeny *et al* 1996 & Uphoff 1998.

[24] Kaye (2001) notes that issues considered included the magnitude of the problems facing fisheries, cooperation, monitoring and information, gear impacts and bycatch.

1.5.2 The UN Conference on Environment and Development (UNCED)

The Rio Declaration on Environment and Development reflected a global consensus to move towards integrated environmental, social and economic objectives in natural resource management. Agenda 21 presented a detailed blueprint for change, reflected in Chapter 17 for fisheries and the marine environment (United Nations 1993; Australia 1996). Whereas the LOSC set the legal rights and responsibilities of states and the basis of international cooperation, Agenda 21 identified policy issues that were based on gaps in international law (Garcia 1996). It aimed to identify new approaches to management that were 'integrated in content and are precautionary and anticipatory in ambit' (United Nations 1993).

Chapter 17 listed seven program areas [25] all of which are partly relevant to fisheries management. Two programs specifically deal with fisheries on the high seas and under national jurisdictions (United Nations 1993). Both programs focused on an increased commitment by States to the sustainable use of fisheries resources. They highlighted the restoration of depleted populations, development of gear that minimises by-catch, discards and waste, ending destructive fishing practices (such as dynamite and poisoning), and the improvement of research, monitoring and management measures (International Oceanographic Commission 2001; Kaye 2001). Agenda 21 also reiterated the dominant management principle identified in the LOSC: maintaining stocks at levels that can produce maximum sustainable yield as qualified by relevant environmental and economic factors (United Nations 1993) The precautionary principle was widely espoused in UNCED, but at the time no consensus had been reached amongst fishing nations on its specific application to management. The principle, while detailed in a pollution context within UNCED and Agenda 21, was subsequently not expanded to cover fisheries management (Kaye 2001).

Agenda 21 succeeded in highlighting the critical issues to be addressed by fisheries in the coming years and set an agenda that gained international recognition. This agenda has fed into national and international policy instruments, management programs and tools designed to move towards sustainable fisheries. A critical outcome from Chapter 17 was the recommendation to

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25 Integrated management of coastal areas; Marine environmental protection; Sustainable use of marine living resources of the high seas; Sustainable use of the living resources under national jurisdiction; Climate change; Strengthening international and regional cooperation; and Islands (United Nations 1993).

convene a conference into the issue of straddling and highly migratory fish stocks, an issue critically linked to the management of high seas stocks and coordination between states. [26]

1.5.3 The UN Fish Stocks Agreement (UNFSA)

The UN Fish Stocks Agreement (UNFSA) [27] was developed over six sessions between 1993 and 1995 with some 148 States and UN agencies, international bodies and non-government organisations (Juda 2001). The agreement recently entered into force in December 2002 with the 30th instrument of ratification (CIESIN 2003). Its objective was to negotiate an agreement to clarify the responsibilities of fishing states with respect to highly migratory species and straddling stocks, to provide coordination for management via regional fisheries management organisations, and strengthen fisheries management on the high seas (Yuile 2000; International Oceanographic Commission 2001).[28] The LOSC placed approximately 90-95% of the oceans under coastal state control through the creation of EEZs (Smith 2000), but significant issues remained over the management transboundary stocks. Stocks 'straddling' the EEZ boundary from the high seas were subject to a different legal regime on both sides of the boundary, and often fished by international fleets outside the jurisdiction of the coastal state. In addition, stocks migrating between several EEZ and high seas areas (such as tuna) were subject to often conflicting management measures by different states or high seas arrangements.

The UNFSA was developed consistent with the obligations under the LOSC, but it represented a significant progression of international law (Juda 2001). In addition to providing measures to manage straddling, migratory and high seas stocks, the agreement codified the ecosystem approach to fisheries management (Caddy 1999; Stokke 2000).

Principles in the UNFSA included:

- Unity of stocks and the need for management of stocks over their entire range; [29]
- The need for compatibility of EEZ and high seas regimes; [30]
- Non-target species considerations and the interdependence of stocks; [31]

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[26] Section 17.49 (e) (United Nations 1993).
[27] Full title is the UN Agreement for the Implementation of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks 1995 (UNFSA).
[28] Further detail on the UNFSA can be found in Berkes et al 2001; Caddy 1999; and Garcia & Hayashi 2000.
[29] Articles 5 & 7 (CIESIN 2003).
[30] Article 7 Ibid..

- The need for a precautionary approach to fisheries management, [32]
- Transparency in decision-making and the inclusion of stakeholders in regional fisheries management organisations. [33]

The UNFSA pays attention to the precautionary approach and declares that states should apply this approach to the conservation, management, and exploitation of straddling and migratory fish stocks (Herriman et al 1997). The precautionary approach, as it applies to fisheries, was expanded during the negotiation of the agreement. Applying precaution under the agreement focused on improving decision making in the face of uncertainty, sharing scientific information, risk assessment, and the application of stock target and limit reference points (Garcia 1994; International Oceanographic Commission 2001).

1.5.4 FAO Code of Conduct for Responsible Fisheries

The FAO Code of Conduct is a ‘soft law’ instrument, voluntary in implementation, and has significantly progressed ecosystem and precautionary approaches into management regimes (Garcia 2000; International Oceanographic Commission 2001). The development of the FAO Code of Conduct for Responsible Fisheries in 1995 was a significant turning point in fisheries management, developed in the context of the principles presented in the UNCED, Agenda 21 and the UNFSA (FAO 1995). The Code is directed at ‘all members and non-members of FAO, fishing entities, subregional, regional and global organisations, whether governmental or non-governmental, and all persons concerned with the conservation of fishery resources and management and development of fisheries’ (FAO 1995). The structure of the code is based on practical application and addresses the actors required to implement it: policy makers, fishery managers, fishermen, farmers, processors and traders, and scientists (Garcia 2000). Despite the soft law nature of the instrument, the Code has formed a de facto international benchmark for management objectives.

The Code sets out a number of issues and principles that affect all forms of fishing (FAO 1995). Issues include:

- Responsible Fishing Principles; [34]
- Fisheries management; [35]

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[31] Articles 5 & 6 Ibid..
[32] Articles 5 & 6 Ibid..
[33] Article 12 Ibid..
[34] Article 6 (FAO 1995).

- Fishing operations; [36]
- Aquaculture development; [37]
- Integration of fisheries into coastal area management; [38]
- Post harvest practices and trade; [39] and
- Fisheries Research. [40]

The precautionary approach undergoes significant expansion in the Code, [41] signalling its continuing acceptance as a management objective. This expansion of the precautionary approach highlighted the fact that fishing nations had moved away from the position of predominant belief of precaution representing a *moratorium* (Kaye 2001) to seeing precaution as a *process* that focused on uncertainty in implementation and development of rational decisions in the face of this uncertainty. Uncertainties should be accounted for in setting objectives and targets that relate to the size and productivity of the stock, fishing impact on the stock and non target species, and broader environmental and socio-economic conditions [42] (FAO 1995). It promotes the concept of stock specific target reference points and limit reference points (FAO 1995). In addition the Code gave consideration to new or exploratory fisheries, stating that States should adopt cautious conservation and management measures when developing these resources (FAO 1995, Caddy 1999).

Ecosystem concerns are also present in the Code of Conduct in the form of general principles. Ecosystem concerns have evolved to consider the *entire* system, including human components, and the Code recognises this through integrated management of target, ecosystem, social and economic issues and the establishment of measurable objectives for these dimensions (Ecosystem Advisory Panel 1999). The conservation of species that are associated with or dependent upon the target stock is an overarching principle in the code with the preparation of management measures a significant recognition of an emerging ecosystem ethic. [43] The research agenda set by the Code [44] specifically recognises the need for information to support ecosystem-based management (FAO 1995).

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[35] Article 7. Ibid..
[36] Ibid. Article 8.
[37] Ibid. Article 9.
[38] Ibid. Article 10.
[39] Ibid. Article 11.
[40] Ibid. Article 12.
[41] Ibid. Article 7.5.
[42] Ibid. Article 7.5.2
[43] Ibid. Article 6.2.

Since the development of the UNFSA and the FAO Code of Conduct, fisheries management has evolved to consider ecosystem-based management and precautionary methods as core concerns. Significant research, information and tools are required to progress towards these objectives. Recently the 2002 World Summit on Sustainable Development declared that the ecosystem approach should be the mainstay of fisheries management by 2010 (United Nations 2002c). In addition it stated that by 2012 tools should be available to facilitate the ecosystem approach, the elimination of destructive fishing practices, and the establishment of marine protected areas (United Nations 2002a; United Nations 2002d). A key outcome of the summit was the declaration and internationally agreed objective to maintain or restore global depleted fish stocks to levels that can produce the maximum sustainable yield by 2015 – a significant challenge. [45]

1.6 Fisheries Sustainability

1.6.1 Towards integrated fisheries

Traditionally fisheries management has focused on the outputs of the target species through stock assessment techniques, but in recent years new emphasis has been placed on the dynamics of the ecosystem as a whole (Charles 1998a; Potts 2001; Pauly et al 2002). A variety of factors influence the system outside target stock output. These factors consist of economic, social, institutional and ecological components and bear a significant impact on the direction and success of the use of fisheries resources (Charles 1995; Garcia 1996; Ecosystem Advisory Panel 1999).

The past traditional views of management will not ensure the ongoing viability of fishery systems under complex competing demands. This problem declares the need for an integrated approach that takes into account fishing as an industry, as a socio-cultural foundation for people, and as a complex interrelated ecological system (Charles 1997; Charles 1998a; Fisheries 1999). With the disciplinary focus on biology and to some extent economics, conventional approaches have avoided the socio-economic needs of fishing populations and the effects of the fishery on the ecosystem. Management is now orientating towards the development of assessment and implementation systems that take into account the critical, interrelated dimensions of fisheries exploitation (Ward et al 2002).

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[44] Ibid. Articles 12.1 to 12.20

[45] This declaration was hailed as a significant breakthrough in the international negotiations and one of the first agreements to come out of the WSSD. This outcome however is perceived a 'two-edged sword', the positive aspect an agreed global target and recognition to restore stocks, but Maximum sustainable yield (MSY) is perceived as an outdated and high-risk strategy that is embedded in a single species approach.

Orientation towards sustainable approaches involves reconciling the often-conflicting objectives that have impaired coordinated decision-making. Approaches will have to face the traditional objectives of resource production and development as well as objectives related to socio-economic and ecosystem management. This includes the investigation of co-management and participatory approaches, integrative governance arrangements, and ecosystem relationships. The key challenge lies in the application of objectives and principles into a practical management focus with measurable outcomes. The discussion below highlights the integrated nature of fisheries problems and the means to address them.

1.6.2 Underlying conceptual problems in fisheries

The fact that a fishery crisis is upon us is evident with statistics highlighting declining marine fishery catches coupled with increasing pressure from a rapidly growing global population with a demand for seafood product. Overcapacity - too many boats chasing too few fish - is a critical issue, with the world's fishing capacity greatly exceeding what is needed to catch the sustainable yield (Buckworth 1998). The capacity of stocks to provide for increased and continual demand is limited with FAO statistics highlighting approximately 70% of stocks, for which data is available, as fully exploited, recovering or depleted (FAO 2000). The serious situation facing global fisheries is highlighted by the decrease in mean trophic levels of catch: large long-lived species are being replaced by smaller, short-lived species (Pauly et al 2002).

To develop new management approaches to address the emerging crisis, it is necessary to identify the underlying problems and to place them within the context of emerging sustainability initiatives. The identified problems include overcapacity, uncertainty, the stock assessment paradigm, information issues and insularity amongst disciplines (Charles 1995).

1.6.3 Overcapacity

Overcapacity refers to an excess of effort that is required to harvest fisheries resources within sustainable limits (Buckworth 1998). Overcapacity has arisen due to a combination of technological and socio-economic forces. Over the last century, the rapid increase in technology and catching capacity has affected the ability of fleets to harvest stocks. In commercial fisheries, fishing techniques, vessel design, and the use of electronic gear has rapidly evolved. Improved technology can affect fisheries in many ways – new grounds can be accessed further offshore and in deeper waters, new stocks can be located and captured, and vulnerability can be increased. An important point is that declines in stocks can often be hidden by increases in technology - catch levels (or levels of effort) can be maintained per unit of time due to the increase in efficiency and capability of fishing.

Capacity tends to build up during good seasons – periods of development and support and good stock recruitment or prices - with the goal to increase future revenues. Governments can also establish programs to increase the capacity and effort within a fishery. When the fishery stabilises or slumps, government assistance may be required to prevent unemployment or loss of investment. The consequence is the intense pressure to maintain the fishery at a high exploitation rate. It is a difficult situation to reduce effort when such pressure is placed upon development and growth and jobs are at stake. Overcapacity is an issue that has many socio-economic and management factors behind it, and its solution will be complex and difficult. One point is clear however; it represents a critical factor in affecting fisheries sustainable development.

According to (IUCN 1998) official records show the capacity of the world's fishing fleet increasing by 4.6% per year between 1970 and 1990, twice as rapidly as catches. The report, which included advances in technology efficiency as well as growth in the size of the fleet, estimates that capacity may have increased by as much as 155% in this period. Much of this growth has been underwritten by subsidies – the annual world catch is estimated to be worth US$70 billion but to obtain this an estimated US$22 billion is provided by government (IUCN 1998). Overcapitalisation is aggravated by the provision of government subsidies that promote fishing activity beyond levels that stocks can support. However it should be noted that subsidies can also provide a positive force for fisheries change, including vessel and licence buy back and investment in impact minimising gear.

1.6.4 Uncertainty

Uncertainty pervades all aspects of the fishery management process. The variable nature of the resource and the scientific methods in assessment has resulted in uncertainty as an inherent feature of management (Charles 1994, Charles 1998b). It is difficult to predict resource status, the yield to be produced, the future effects on stocks from environmental influences, or the response to effort (Charles 1994). In addition errors exist in fisheries data, models for stock assessments are oversimplifications, and uncertainty exists within the process of management itself (Buckworth 1998). These components interact to increase the unpredictability and potential risk within the management process. Uncertainty reflects the probability that an estimate or management action may be incorrect and increases the risk of overfishing with ecological and societal impacts.

The assessment of stocks is an essential component of fisheries management. Most management regimes depend on assessments of the stock to determine their abundance and their productive potential. Assessing fish stocks is a difficult exercise for two reasons. The first centres on the difficulties of modelling and estimation of a stock that is impossible to directly count and is highly variable (Charles 1998b). The second difficulty arises, as a stock exists as a part of a complex oceanic ecosystem that includes food web relationships and the effects of physical environmental variability (Buckworth 1998; Charles 2002). Berkes et al (2001) and Charles (2002) identify a typology of uncertainty based on an imprecise knowledge of fish stocks and ecosystems:

- **Measurement error** refers to error present in the observed qualities such as the catch or the life history parameters, e.g. sample surveys can lead to errors in sample size and representativeness, landing statistics can be biased due to discarding, and biological parameters can be expensive and difficult to monitor.
- **Environmental error** refers to the natural variability associated with fish production systems and the variability inherent in physical environmental processes that influence stocks. Little headway has been made on the prediction of the environmental conditions or the associated response from stocks.
- **Model error** occurs due to the misspecification and design of predictive biological models. Models are an attempt to synthesise reality and base predictive assumptions - errors in the parameters (measurement error) and error in the model design can significantly influence results. Studies on the performance of models suggest that they may provide substantially different answers using the same data sets (Sharp 1996)
- **Estimation error** results from any, or a combination of, the above uncertainties in terms of the results of model outputs. The sequential nature of the process means that errors can occur at several stages and are propagated through the process.

In addition to uncertainty based on the stock and its characteristics, problems can arise from the dynamics of management, authority and uncertainty in institutional process (Charles 1994; Charles 2001; Essington 2001). Charles (2002) refers to this as implementation error but it is also referred to in the literature as management uncertainty and process uncertainty (Committee on Ecosystem Mgt 1999). Implementation uncertainty results from the variability in the implementation of management responses by stakeholders, and recognises that there are limitations to the extent that management can control exploitation. This form of uncertainty is influenced by ineffective surveillance and compliance mechanisms, lack of involvement in decision-making, and the general failure of the management system to take into account socio-economic and cultural information. Furthermore, uncertainty is magnified in the context of the insularity between scientific disciplines related to fisheries activity, research and management (Pontecorvo 2003). Multidisciplinary approaches are required to increase the flow of information between scientists, policy makers and managers. Stakeholder support and communication are often seen as vital components to an effective management regime, yet uncertainty in authority, security, ownership and participation pervades the process. Uncertainty in management can lead to pressure to overfish, as evidenced by Buckworth (1998) and Charles (1998b). The authors noted that in the Canadian Atlantic groundfish fishery of the 1970's, a top down management approach invested minimum power with fishers and created uncertainty that resulted in pressure for non-compliance rather than social pressure for adherence to regulations.

1.6.5 The Stock Assessment Paradigm

The science of fish stock assessment, while fraught with error and uncertainty, has been the dominant paradigm in management. Fisheries science evolved from early empirical observations, through a post World War II period of theoretical development, to a stage of parameterisation of biological characteristics (Sharp 1996). From the 1950s a number of prominent biologists developed models on fish stock assessment. Schaefer, Beverton and Holt, and Ricker produced a set of models that defined the total sustainable yield for a given stock of fish, and are still in use in management today (Harden-Jones 1994, Sharp 1996).

Earlier models attempted to explain the dynamics of stocks under fishing pressure. Scientific evidence established that stocks were not only self renewing, but the rate of renewal was dependent on the share left after exploitation and the biological characteristics of the species (Charles 1994). However, once the population fell below a certain size its ability to regenerate was limited with insufficient numbers to regenerate the stock. The concept of maximum sustainable yield[46] (MSY) grew out of these investigations. MSY has remained a dominant force in fisheries management and has formed the basis of a management standard for fisheries over the world. The MSY paradigm advises the steady increase of fishing effort until a decline in yield signals that the maximum sustainable fishing level has been reached. This is followed by

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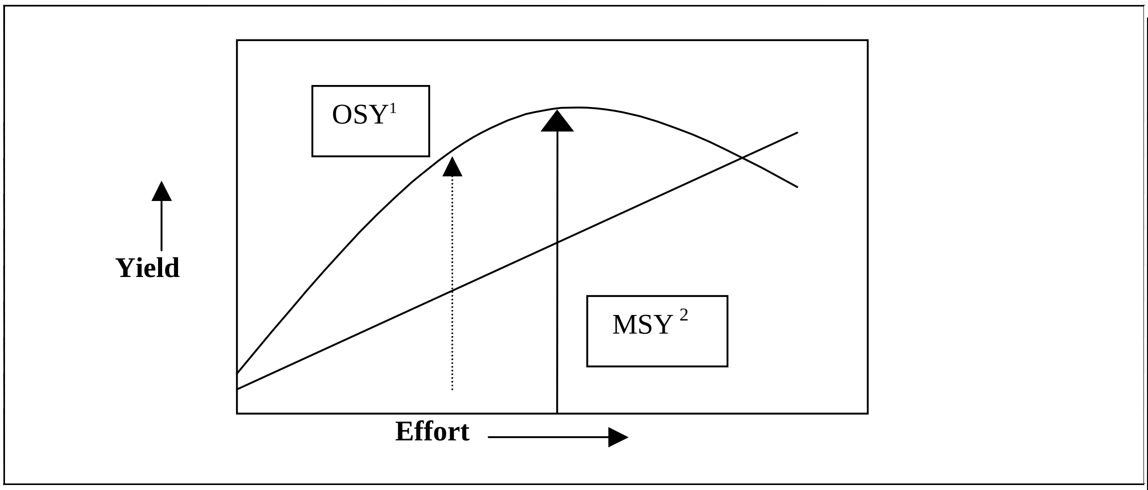
[46] There is a great deal of literature on the development, use and evolution of MSY. For a detailed analysis of this issue refer to Larkin 1977; Gulland 1983; Harden-Jones 1994; Iversen 1996; and Sharp 1996. This list is by no means exhaustible, but is a good summary of the issues.

reduction of the effort to the optimum level (Buckworth 1998) (Sharp 1996). The theory aimed to set the greatest catch that can be removed from a stock each year without impairing the ability of that stock to renew itself (Harden-Jones 1994). MSY is demonstrated with an effort/yield diagram below in Figure 4.

From Figure 4 it can be observed that with an increase in effort there is a corresponding increase in the yield from the fishery. The greater the effort the higher the yield. However, a turning point will be reached when the stock falls below a level where it can regenerate itself. Increased effort in the fishery will lead to a lower yield and overfished stock. The point on the graph that provides the greatest return for effort without causing the reduction of the population is the MSY.

Figure 4. Maximum Sustainable Yield Diagram (Bell & Morse 1999)



1. Optimum Sustainable Yield.
2. Maximum Sustainable Yield.

Many criticisms exist of MSY as a management target. The concept, once seen as the basis of responsible management, has essentially failed in its approach to ensure sustainable fisheries. Several examples exist of fisheries that were managed to MSY and resulted in overfishing (the Peruvian Anchoveta and North American cod stocks). MSY failure can be attributed to the inherent uncertainty of stock assessment and the unpredictable nature of fish stocks - resulting in errors in calculation. Another critical factor occurs during the identification of the target level of fishing to determine the MSY level. Calculation requires a steady increase in effort until a decline in yield signals that the optimal level had been reached. A reduction of effort is then required to reach the sustainable level. In practice, it is difficult to scale back effort under political pressure for maintaining catch rates and the uncertainty in the assessment, leading to possible overfishing of the stock. An increasingly precautionary approach to management is required.

MSY is a single species approach and does not take into account the interactions with other species or the variability in stocks from environmental influence (Sharp 1996; Buckworth 1998). It also avoids socio-economic considerations in determining the yield, though this has been included in the practice of identifying the Maximum Economic Yield.[47] Over it's life of practice MSY has evolved to become a limit reference point for management that should not be exceeded rather than a target. Increasingly a safety margin is required in management with 2/3 MSY recommended as a target reference point.[48]

1.6.6 Open access, incentives and the 'commons'

The notion of open access and the commons, and the regulatory means to control the actions of fishers has long been an issue discussed in the literature. [49] As important to the discussion on access to resources are the socio-economic incentives and regulatory regimes that direct fisher's behaviour and contribute to unsustainable practices.

Mare liberum, or 'freedom of the seas' (Grotius 1604) set the conceptual framework for human interaction with fisheries resources under what is known as open access or common property (Hall 1998). (Berkes et al 2001) defines common property resources as a class of resources for which exclusion is difficult and joint use involves subtractability.[50] Fisheries resources were considered open access, especially on the high seas, with such an approach leading to overfishing (Berkes et al 2001). A famous essay by in 1968 termed the 'Tragedy of the Commons' highlighted the dilemma faced when common property resources are used by economically rational, individualistic actors (Hardin 1968). In Hardin's story, resource users in a 'commons' (Hardin used the example of cattle owners in common pasture) gradually increase the size of their individual harvest with no incentive to conserve due to the fact that each

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[47] MEY deals specifically with the profitability of enterprises engaged in fishing. See Berkes et al (2001).
[48] In recent times the concept of Optimum Sustainable Yield (OSY) has often been discussed in fisheries management Stroud (1975) identifies OSY as "The largest net economic return consistent with the biological capabilities of the stock, as determined on the basis of all relevant economic, biological, and environmental factors." Although deemed useful, the difficulty lies in assessing the different components (economic, environmental and social) and incorporating these assessments into the yield calculations – with the end result often vague or miscalculated.
[49] For discussions on open access and the issue of the commons see Schram 1995; Feeny 1996; Hall 1998; and Berkes et al 2001.
[50] Subtractability refers to a problem in fisheries and common property resources, where the catch taken by one fisherman affects the current productivity of other fishermen as well as the future productivity of all fishermen through its effects of the stock (Feeny 1996). Subtractability, or rivalry, is an inherent feature of marine resources.

individual wishes to maximise. The collective behaviour eventually exceeds the carrying capacity of the ecosystem and leads to ecological collapse – hence the tragedy in Hardin's essay (Hardin, 1968; Uphoff 1998). The tragedy of the commons has been extensively applied to fisheries circumstances. Fisheries have the criteria for meeting common property scenarios – resource exclusion is difficult and the incentive is to catch quickly and beat competitors rather than conserve the resource (Feeny et al 1996). Therefore addressing solutions to this problem and ensuring the sustainability of fisheries involves controlling access to the resource and establishing 'rules' to solve the divergence between individual and collective rationality (Hardin 1968; Committee on Ecosystem Mgt 1999). The establishment of fishing rights, reduction of open access fishing to regulated regimes and increased stakeholder and community involvement have been cited as responses to the open access problem.

1.7 Moving Towards Fisheries Sustainability

The underlying conceptual problems in fisheries are a complex mix of scientific, socio-economic and management issues that have evolved over the long term. With their scope and diversity, a 'one size fits all' approach will not remedy the situation. What is needed are tools and a management paradigm that recognises the inherent complexity of fisheries exploitation and management, the socio-economic and ecological dimensions, the uncertainty of information in the system and the need for incentives that encourage involvement, participation and ownership of the resource. The causes of the degradation of fisheries sustainability have been identified for many years and discussed at the national and international levels. Policy responses have been expansive with the proliferation of many international agreements and strategic targets. Practical and measurable responses that can contribute to resolving these problems at all scales of activity are pressing needs.

The integrated nature of the problem is a recurring theme in management. Policy development must face the realisation that fisheries problems are not only scientific or biological in nature, but have scientific, social, economic, and institutional components (Lane 1996; Pontecorvo 2003). Management responses need to take account of these factors. [51] Ecosystem-based management and the precautionary approach are a key area for conceptual and practical development in fisheries, as they directly address these interrelated factors. These management

[51] The interrelated nature of the problem of overcapacity is a good example. In a local, individual fishery economic forces and social pressure can lead to overcapacity, which make it difficult to reduce effort. Excess effort from overcapacity can cascade from fishery to fishery and has become a regional and global problem (Buckworth 1998 & ISOFISH 1999). Mechanisms to reduce capacity should not result in the export of capacity. Solutions must address the integrated nature of these problems.

approaches recognise the inherent complexity in exploitation and management systems. While being at an early phase of application, they form the basis for establishing improved decision making tools.

1.7.1 Ecosystem-based management (EBM)

In recent years, policy systems at the national and international level have expanded to explore ecosystem-based management. This is particularly acute in the development of Oceans Policy regimes that set the objective of integrated management and attempt to manage amongst competing users of ocean resources in an ecosystem context (Commonwealth of Australia 1998a; Ministerial Group on Oceans Policy 2001; Government of Canada 2002b; Haward 2002). The call for an ecosystem approach has arisen as a response to recognition that single species approaches have not achieved sustainability for the resource or the users, and that target species exploitation is observed to affect marine ecosystems [52] (Pauly et al 2000; Pauly et al 2002). Current management approaches are characterised as being concerned with 'conservation of the parts' of systems as opposed to the interrelationships between them. Ecosystem-based management explicitly acknowledges that fisheries operate within broader ecological and socio-economic systems that influence each other.

In the context of fisheries management, EBM directly calls for an expansion of the target species approach to include ecosystem factors in decisions. Ecosystem factors can be interpreted as the effect of the fishery on the broader ecosystem, and the effect of the ecosystem on the fishery (Arbour 2001; Sainsbury, 2001; Everson 2002; Ward et al 2002). EBM also has expanded to include consideration of human induced factors within the fishery as these issues directly relate to management success. Socio-economic concerns are critical and must be taken into account when making decisions and managing the fishery (Bowen 1996).

Considering the effects of the fishery on the ecosystem is an important component of EBM. Expansion from the single-species status and control strategies to a holistic perspective raises questions for information and governance mechanisms (Murawski 2000). Management consideration extends to the associated and dependent non-target species. Associated species can be caught as bycatch in the fishery and do not necessarily have a direct functional feeding relationship to the target species (Fletcher et al 2002). An example is the incidental catch of

[52] Pauly *et al* (2002) have described the ecosystem effect of fisheries with the fishing down marine food webs theory.

albatross and seabirds in demersal long-line fisheries. Dependent species maintain a functional ecological relationship with the target species (Harden-Jones 1994; Botsford 1997). Harvesting of the target stock can directly affect these species through the alteration of trophic food web relationships (Pauly et al 2000; Ward et al 2002). In addition, the effects of harvesting on habitat are important considerations (e.g. trawling on seagrass beds). This includes habitat that affects the fishery, such as coastal nursery sites, and ecosystem components that are directly and indirectly affected by the fishery (Arbour 2001; Ward et al 2002). In terms of human systems, the consideration of how the fishery affects human behaviour and socio-economic structures is an important development. Coastal communities are inherently reliant on fishery systems for food, employment, and cultural tradition (Berkes et al 2001). Decisions in the fishery will have a variety of socio-economic ramifications in dependent communities. EBM aims to make these explicit and involve the stakeholders in co-management exercises.

The effects of the ecosystem on the fishery are considered the other half of EBM. It relates to the effects of the physical environmental variables on the marine ecosystem such as temperature, currents, and salinity. Understanding the relationship of the environment to the fishery in terms of natural variability will improve the understanding of the ecological relationships in the system (Arbour 2001). Another important issue is reconciling the management between coastal and fisheries systems. Historically coastal and fisheries management efforts have evolved separately addressing different needs (Juda 1999). Emerging evidence suggests that land and estuary based activities can affect the health of marine ecosystems and fisheries through pollution, development activities and fractured governance (Juda 1999).

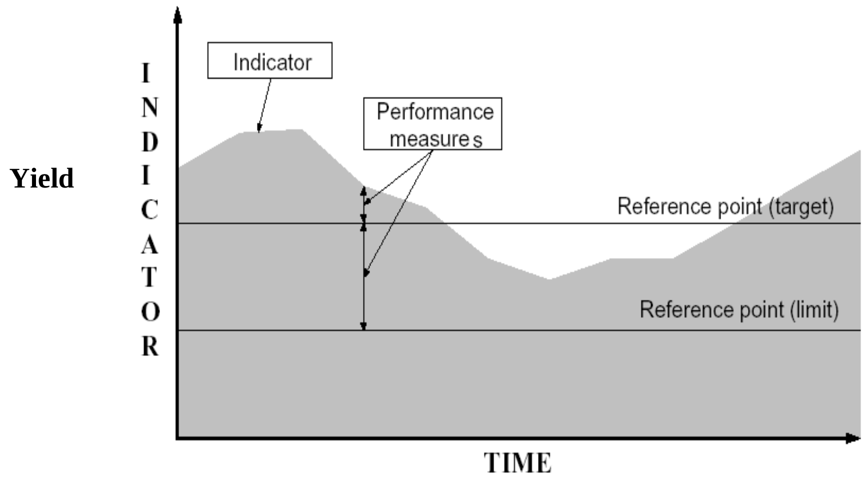
To date EBM initiatives have focused on setting strategic objectives (Ecosystem Advisory Panel 1999). These objectives are conceptual in nature, reflecting the limitations in knowledge about marine ecosystems (Sainsbury 2003). The setting of conceptual objectives is important for identifying the actions required by the institution to implement EBM. The next stage is to define specific practical tools and measures that contribute to achieving the conceptual objectives. The process needs to remain transparent for stakeholders to ensure ‘buy in’ and to display how specific actions were formulated on the basis of the objectives. In addition, the process needs to be scientifically defensible, cost effective, and pragmatic for management implementation (Sainsbury 2003). The results from this process will be used in the management system and will have ramifications for management decisions, reporting, and performance assessment. The process of establishing sustainability indicators is identified as a means to implement ecosystem-based management (Ecosystem Advisory Panel 1999) (Sainsbury 2003) and is explored in detail in Chapter 2.

1.7.2 The Precautionary approach

As stated earlier fisheries operate within a climate of uncertainty. This uncertainty derives from a poor knowledge of the biological resources and the ecosystem, the methods used to assess and observe them, and the uncertainty inherent the formulation and implementation of management approaches (Garcia 1994; Charles 2002). As a result of this uncertainty, a management concept termed the 'precautionary approach' has emerged. The precautionary approach emphasises foresight and recognises that fishing can have unpredictable and irreversible effects on marine ecosystems (Essington 2001). It recognises uncertainty as an element of management that cannot be avoided (Charles 2002). The practice of precautionary management therefore emphasises guidelines intended to prevent overfishing and to rebuild stocks.

A precautionary approach, in its most basic form involves 'erring on the side of caution' when making decisions in a climate of uncertainty (Charles 2002). Methods of developing a precautionary approach include the identification and development of reference points for fisheries that identify desired states (targets) or undesirable states (limits) for a particular variable or indicator (Garcia 1994; Caddy 1999; Charles 2002; Essington 2001). The performance of a variable can be assessed over time in relation to the reference point (Figure 5).

Figure 5. Target and Limit Reference Points



(Adapted from Sainsbury 2003)

Reference points are effective when they are linked to a management response as they approach the target or limit. Initial FAO investigations of setting precautionary reference points determined target and limit reference points based on fish stock assessment models (Caddy

1998). The UNFSA used the approach of setting MSY as a limit reference point for stock conservation. These approaches, while certainly progressive in terms of setting a quantitative standard for the precautionary approach contain a number of limitations.

Primary among these limitations is that the approach can only be applied to fisheries that have comprehensive stock assessment data. In addition, the MSY theory is inherently uncertain as it is a single species approach that does not apply to the whole ecosystem (Halliday 2001; Fanning 2002). Past estimations at stock abundance can contain up to two-to-threefold error margins (Sharp 1996; Essington 2001). Recent developments in setting reference points have investigated their use in a wider range of ecosystem and socio-economic contexts (Sainsbury 2003). Particular effort has focused on the setting of ecosystem based reference points (Arbour 2001; Sainsbury 2003).

The setting of reference points is one way of establishing a precautionary approach. However further conceptual development has shown that implementing a precautionary approach involves the development of a system-wide adaptable management process to account for uncertainty and error and must be flexible to respond to unexpected changes (Charles 1997; Charles 1998a). Essential elements of a precautionary approach within a fisheries management system will include the setting of objectives, strategies to achieve the objectives, indicators, and targets to measure progress and decision rules to cycle information back into management. The precautionary approach therefore entails the creation of improved and inclusive methods for assessing resource status and monitoring and reporting across whole contexts, including ecological, socio-economic and institutional parameters (Sharp 1996; Garcia 2000; Berkes et al 2001). It can be argued that increasing monitoring across multiple dimensions could increase uncertainty, especially when fisheries have expressed difficulty in monitoring single stock populations. However, monitoring the full range of factors that influence the fishery system as a whole is necessary to ensure the ongoing viability of that system and its interrelated components.

1.7.3 Conclusion

The emergence of EBM and precautionary approaches as core elements of fisheries management heralds a shift in traditional management practice. Single stock methods, while still crucial for management of the fishery, are being expanded to account for the influential ecological and socio-economic systems, and are setting the basis for integrated, objective based decision-making. The precautionary approach calls for cautious decisions in a climate of uncertainty and management systems that are adaptable and contain measurable objectives, strategies and targets to meet multiple goals.

These developments require significant research and application. At present solutions have not generally moved past the conceptual phase. There is a real need for tools and pragmatic methods that serve to implement EBM and the precautionary approach. Institutions have identified objectives but the focus has shifted to the identification of tools and information systems to implement these objectives. Success stories and working examples of the practical implementation of EBM and precaution are needed to guide new endeavours. The development of sustainability indicators is a means of implementing EBM and precaution through establishing multi-dimensional, objective based, integrated and adaptable management systems. Indicators and indicator systems are expanded in the following chapter.

Chapter 2: Indicators of Sustainability

2.1 Introduction

The proceeding chapter suggested that for sustainability to be effective, it had to be translated into practical measures to address the needs of sectors such as fisheries, forestry, agriculture or tourism. It is through this 'customisation' that the concept can be applied in practical dimensions to the real world. Once general principles of sustainability are interpreted into context, objectives can be established in legislation, policy or consensual agreement. Sustainability assessments must target the effects of a particular activity but also determine its contribution to a broader societal goal of sustainable development (Bossel 1999; Chesson 2000). A development may be sustainable *in situ* (e.g. a fishery, a forestry operation, or a tourism activity) but this activity may conflict with a particular societal goal or reduce a valuable resource.[53]

To measure our progress towards this goal, a reliable system of measurement is required. Measuring performance and of using indicators to convey information has existed for centuries (Meadows 1998). Indigenous cultures have used indicators for thousands of years to determine suitable times for food production and other aspects of living off the land (Berkes et al 2001). A simple sign in the environment has conveyed and simplified complex environmental processes that are relevant for the survival of a society. In an economic sense, a single indicator has judged people: their wealth. Whether the parameter of measurement is land, money, or property, an indicator of wealth represented the ability to live with security (Bossel 1999). Economists have used gross domestic Product (GDP) as a single measure of the status of national growth.[54] This single indicator has driven policy responses from national governments and has been an important influence in macro-economic policy. In recent years however, GDP has been seen as simplified measurement that does not account for all aspects of 'growth' in a national economy, not taking into account social and environmental aspects of national wellbeing (Bossel 1999;

[53] For example logging of an old growth, high conservation value forest or exploitation of a fish stock with a high bycatch rate of a valued species would generally conflict with social goals despite the resource being 'sustainable'.

[54] The GDP is the total money value of the annual flow of goods and services produced in an economy. It leads to perverse outcomes and interpretations in terms of examining the well being of a nation. To give an extreme example a serious road trauma increases GDP through expenditure on services and goods required to deal with the outcomes of car accidents.

Hundloe 2000). This highlights the inadequacy of a single indicator to capture the complexity of a particular situation and the caution that must be exercised during the aggregation of information.

The past decade has witnessed an increasing interest in, and applied work on, the use of indicators to monitor change. The development of useful indicators requires not only an understanding of concepts and definitions, but also a good knowledge of policy needs. A key determinant of a good indicator is the link from measurement to practical policy options. As discussed in Chapter 1, indicators can be used at several scales as a tool for environmental, social or economic reporting, performance assessment, and reporting on progress or clarifying objectives and priorities for sustainable development.

2.2 Conceptualising Sustainability Indicators

2.2.1 A working definition

The OECD pioneered the conceptual work on environmental and economic indicators. Its simple definition applies to all indicators in use today (OECD 1994; 8):

> *An indicator can be defined as a parameter, or a value derived from parameters, which provides information about a phenomenon*.

Indicators are a simple concept. In providing information about a phenomenon (for example an environmental process, economic issue, or social problem) indicators relate signals from complex systems into useable information that can be used in decision-making (Dahl 1995; Bossel 1999). Indicators, as the middle ground between science and policy, must be simultaneously pragmatic and scientifically valid (Jesinghaus, 1999). They are a tool for promoting understanding, consensus building and communication (Hardi & Zdan 1997; Meadows 1998). It is critical to acknowledge that indicators do not provide an alternative to complex quantitative modelling of relevant issues - they are a mechanism to communicate this information to a broader audience. Indicators provide only one tool for evaluations and need to be supplemented by other quantitative and qualitative information in order to avoid misinterpretation. Such information is needed to explain driving forces behind indicator changes.

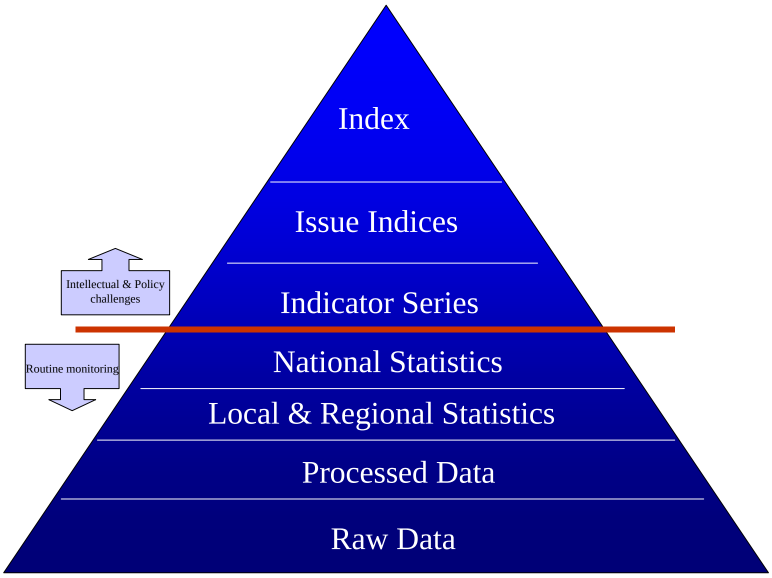
2.2.2 Information requirements for indicators

Indicators take many forms, measure a variety of issues and are used for diverse management purposes. It has proven difficult in practice to identify indicators of sustainability per se*;* often the practice has focused upon identifying activities that contribute to unsustainable states and degraded environments. It is conceptually easier to identify and measure what is happening in reality (i.e. in economic and environmental systems) rather than to measure our progress against a highly abstract notion. Therefore indicators that specifically define sustainability or ecological targets are difficult to identify and are fairly uncommon, though practice is moving in this direction.

Indicators are based on data and transformed into information. This implies a notion of use - once indicators are developed from data (eg. monitoring, historical records, experiments, or interviews) they are used in a decision-making context. This readily separates indicators from statistics – indicators are directly used as the basis of discussion, learning, and decisions and are value laden (Bossel 1999; Dahl 2000). Until recently, their direct use in decision-making has remained limited (Bell & Morse 2001) with exception to economic indicators. As this thesis presents in the case studies, indicator systems are rapidly innovating towards decision support methods.

A typology for information and indicators can be observed through the metaphor of an information pyramid (Jesinghaus 1999) (Figure 6). The base of the figure represents raw data collected by monitoring programs. Progressing through the higher levels of the pyramid, data is processed and condensed into smaller amounts of meaningful information used for informing decisions and directing actions. The dividing line represents a significant split for information use, aggregation and policy relevance. Below the line is the source of the indicator information and ongoing assessment while above the line the information is converted and aggregated into policy relevant indicators. The pyramid highlights the difference between indicators and raw data because they are an element of a specific policy process (*Bakkes et al* 1994). Just as the concept of sustainability was progressively broken down into meaningful scales in Chapter 1, the development of indicators follows an inverse trend of being progressively refined from raw data to an aggregated index.

Figure 6. The Information Pyramid.



(Adapted from (Jessinghaus 1999).

2.2.3 Functions of sustainability indicators

From a review of the literature, indicators can be observed to implement four overall functions:

- Linking objectives to management to improve decision-making;
- Reporting and assessment;
- Building consensus and participation; and
- Forming linkages and integrating scientific and policy disciplines.

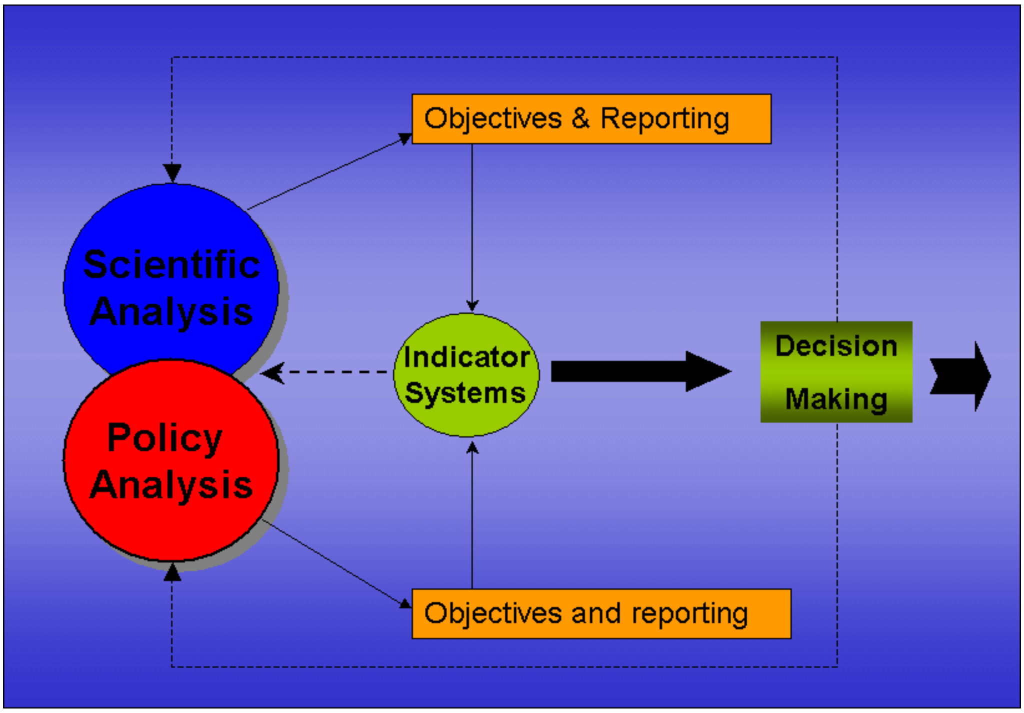
The purpose of indicators is to steer action and provide a sound basis for informed decision-making (Moldan 1997). Effective indicators have a format that is designed with an explicit target group in mind or directed towards a specific policy. They are important tools for translating and delivering concise, scientifically credible information in a manner that can be understood and used by decision-makers (Higgins 2001). Through the process of defining measurements for complex processes, indicators are an important means of linking the conceptual objectives of sustainable development to practical options that can be routinely monitored and assessed (World Bank 1997b; Meadows 1998). This difference from other measures relates to an indicator providing meaning beyond the parameter directly associated with them, usually from comparison with a reference value that delivers a performance assessment (Higgins 2001). Indicators are directly involved in management action and are increasingly effective when linked to management feedbacks and adaptable processes (Bell & Morse 2001). As a result, conceptual objectives can be translated, measured, assessed and understood by stakeholders.

The reporting function of indicators enables specific environmental, social, and economic trends to be examined at several scales. The maxim – if you cannot measure it, it does not count – holds true for sustainability initiatives in government, the private sector and civil society (Hanson 2003). Indicator initiatives have typically focused on separate economic, environmental and social spheres (Higgins, 2001) but systems are now investigating integrated reporting approaches. An example is the increased use of environmental indicators in sectoral and socio-economic policies, especially at an international level with organisations such as the OECD and World Bank (OECD 1994a; OECD 1994b; World Bank 1995; World Bank 1997b; OECD 2001a; World Bank 2002).

A key function of indicators is to build consensus on difficult issues and increase the participation of stakeholder groups and decision-makers. The participation of stakeholders is essential from the outset and can lead to acceptability of the outcomes of the indicator set. Participation increases the ownership of the initiative, improves the coverage of issues and values, and increases acceptability of resulting management decisions (SCOPE 1995; Dahl 1995; Meadows 1998). The participation of relevant decision-makers is also an important point to consider. Indicator effectiveness is influenced by the capacity of the set to influence decisions. Indicators are leverage points that can influence system behaviour (Meadows 1998), but they require the support of decision-makers to do so. Building consensus and engagement is a key task for indicator initiatives and remains a significant challenge.

Indicator development facilitates integration between scientific and policy disciplines (Figure 7). The identification of the conceptual and operational objectives is a policy issue, prone to debate and negotiation. Often objectives and targets are based on accepted policy and legislative outputs (Bossel 1999; Government of New Zealand 2002). The setting of indicator parameters (including monitoring programs, spatial and temporal parameters and performance measures) is primarily a scientific activity, lending rigor to the process. The acceptance and use of indicator results in management reflects on their policy relevance and scientific rigour. Figure 7 indicates that scientific and policy analysis, while related, has minimal overlap and generally conducts separate reporting activities. Indicators bring these fields together and use the results as a driver for integrated decision-making for complex sustainability problems. Feedback then occurs to the respective disciplines and experts. Development of indicators using interdisciplinary ideas and collaboration can lead to integrated co-management approaches (Bell & Morse 1999; DFO 1999a).[55]

Figure 7. The Science and Policy Interface



2.2.4 Indicator Classifications and Systems Approaches

Classification of indicators within an organised framework or operating system is a critical part of their development (Bell & Morse 1999; Chesson 2000; Bell & Morse 2001). Classification can depend on several influences, including operating scale, target sector and audience, practitioner experience in indicator development, financial considerations, regional and cultural influences, policy climate, and the intended use of the set. The ordering of the indicators into a coherent structure clearly identifies how that system measures and reports on sustainability (Hardi & Pinter1995; Hardi et al 1997). A structured approach contributes to consensus building and to the understanding of complex problems. This approach has direct relevance to development of management systems (Bell & Morse 2001). A framework that is transparent and accountable to stakeholders leads to ongoing participation (Hardi & Zdan 1997). In contrast, an indicator set that is poorly designed will send confusing signals to decision-makers and could result in flawed decisions.

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[55] For further detail on an example of indicators facilitating co-management, see the National Case Study: Canada.

The classification of indicators is a theoretical exercise that can contribute to their analysis and improvement. The notion of a ‘perfect’ all encompassing single measure or set of indicators is illusionary. It is important, nonetheless, to identify common classifications and approaches. Bakkes et al (1994) defined three broad groups of environmental indicators: a classification by use (such as a specific policy approach or process eg. an environmental assessment tool), a classification by subject (such as a sector or a theme based approach eg. acidification or agriculture), and a classification by process (eg. pressure, state, response indicators). These approaches can be combined together or used separately.

The World Bank classified approaches according to the degree in which they condense and structure information (World Bank 1997a). Three categories were proposed that included atomistic and individual indicator sets, thematic indicators, and systemic indicators. Atomistic sets represent the least amount of data aggregation and are generally organised as large lists or menus of indicators (sometimes up to or over 100) covering broad sustainability topics (World Bank 1997b)[56]. The thematic approach, generally favoured by nations, involves developing indicators around policy themes and issues, usually selected on the basis of policy priorities. Themes can be different environmental issues (e.g. water, air, or land) or different dimensions of sustainability (e.g. social, economic or environmental). Limited aggregation may occur within these sets, but appears to be rare in existing practice (World Bank 1997a; Moldan 1997; Hyatt 1999). Systematic approaches focus on high levels of aggregation and are complex and ambitious in terms of identifying a single number to determine status (World Bank 1997a). Systematic indicators have often been used in economic initiatives, the most famous (or infamous) being the Gross Domestic Product. Recent initiatives include the wealth and genuine savings indicators produced by the World Bank (World Bank 1997a) or the United Nations Human Development Index.

Organising diverse groups of indicators into coherent and structured frameworks is an important aid to analysis (Bossel 1999). Given that initiatives are nested within a policy and management system and the decision making cycle the effectiveness of indicators cannot be readily isolated from their surrounding policy environment. As a result they must be expressed through institutions that will both generate and use the information and respond to indicator signals (Venning 2001). Dovers (2001) and Venning (2001) identify the growth of ‘informing systems’

[56] An example is the UN Commission on Sustainable Development indicator initiative that identifies large lists of indicators that can be selected by candidate countries to assess sustainability. See UNCSD 2002b.

that consist of a range of processes including data collection, information development, communication tools, and decision-making apparatus. This view encompasses a systems approach as a means to coordinate and implement information for sustainability. This concept is referred to in this thesis as the Sustainability Indicator System (SIS) and is explored in detail in Chapter 3.

Indicator systems take many forms, but generally fulfil the purpose of informing the process of sustainable development. The growth of these systems equates to an expansion of perspectives and practices relating to the assessment of sustainable development with several lessons obtained from comparison of models. There is an explicit recognition in the literature that indicators are useful for delivering information on sustainable development but the add hoc construction of assessment frameworks can also lead to ineffective outcomes. Several questions need to be addressed in developing a SIS and while this thesis proposes a set of criteria to 'guide' the process towards effective outcomes, there are no right or wrong answers simply different approaches to interpreting sustainability based on different policy needs and structures.

2.3 A Chronology of Sustainability Indicator Initiatives

Sustainability indicators have been developed since the early 1980s. International initiatives have been a driving force and focus for indicator science and have influenced initiatives at lower scales and for specific sectoral areas like fisheries[57]. The discussion below identifies several important and influential initiatives that have shaped international indicator development.

2.3.1 The World Commission on Environment and Development 1987

'Our Common Future' highlights that environment and development problems are not compartmentalised within nations, within sectors or within broad dimensions of activity (environmental, economic, social) (WCED 1987). The integrated nature of the problem called for integrated solutions that would require a change in institutional arrangements and objectives at every level. The report noted that the United Nations system, through UNEP, should:

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[57] Several national governments have developed indicators as tools for implementing sustainability policies. Detailed descriptions of the policy instruments that implement sustainability concerns for several nations will be continued in the case studies. The development of specific indicator systems for marine fisheries will be detailed later in the chapter.

- Monitor, assess, and report regularly on changes in the state of the environment and natural resources; and
- Develop criteria and indicators for environmental quality standards and guidelines for the sustainable use and management of natural resources (WCED 1987).

2.3.2 The United Nations Conference on Environment and Development 1992 (UNCED) and Agenda 21

International recognition of the role that indicators can play in making informed decisions concerning sustainable development emerged at UNCED. Ideas concerning the development of indicators as tools for decision-making were certainly prevalent before 1992,[58] but UNCED provided the opportunity for international recognition, collaboration and coordination of initiatives (Dahl 2000).

Recognition of indicators as key tools for sustainability decision-making was articulated in Chapter 40 of Agenda 21, Information for Decision Making (Dahl 2000). The introduction to the chapter states (United Nations 1993; 40.4):

> *Indicators of sustainable development need to be developed to provide solid bases for decision making at all levels and to contribute to the self-regulating sustainability of integrated environment and development systems.*

Chapter 40 specifically calls for the development of indicators as a means to implement and provide the foundation of sustainable development[59]. Section 40.6 states (United Nations 1993; 40.4):

> *Countries at the national level, and international governmental and non-governmental organisations at the international level, should develop the concept of indicators of sustainable development in order to identify such indicators.*

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[58] The Convention of the Conservation of Antarctic Marine Living Resources 1980 (CCAMLR) had initially investigated the use of indicators i in 1985 (Nicol, pers comm). *Our Common Future* (WCED 1987) highlighted the need for information to progress toward sustainable development. It did not specifically refer to indicators but suggested the direction t b hat research should focus upon. In addition the Organisation for Economic Cooperation and Development (OECD) began to develop initial indicators of environmental performance in 1991 (OECD 1994).

[59] Chapter 40 (United Nations 1993) states the following strategies:

(a) Development of indicators of sustainable development (s.40.6)
(b) Promotion of global use of indicators of sustainable development (s40.7).
(c) Improvement of data collection and use (s.40.8).
(d) Improvement of methods of data assessment and analysis (s40.9).
(e) Establishment of a comprehensive information network (s.40.10).
(f) Strengthening of the capacity for traditional information (s40.11).

Chapter 40 aimed to ensure that decisions were based on sound information with proposed actions on bridging the data gap and improving information availability (United Nations 1993). Bridging the data gap clarifies that despite considerable data and information already existing within different sectors there is a need to collect new information for sustainable development. This includes information on the links between environmental, developmental and socio-economic issues, remotely sensed data and specific demographic data (e.g. poverty, health and access rights). Section 40.4 specifically notes that indicators such as gross national product and measurements of resource depletion or pollution are inadequate for assessing holistic sustainability (United Nations 1993).

Improving the availability of information is critical for the development of indicators. While there exists a great deal of information that could be used for the management of sustainable development, accessing this information is a significant challenge for developing countries. Difficulties in terms of costs, technology or the expertise to interpret and use the information can hinder access.

Chapter 40 provided an important starting point for the introduction of indicators as instruments used in informing sustainable development. It highlighted two primary roles for indicators: that of the need to get accurate information existing data and new data, and using indicators as a means of facilitating improved collection and access for developing nations, decision makers and the public.

Ten years later after UNCED, at the 2002 World Summit on Sustainable Development, indicators have been directly and indirectly recommended as tools that facilitate, link and implement sustainability. The Plan on Implementation, building on many areas of Agenda 21, calls for the continued development of partnerships and the inclusion of sustainability principles in all areas of decision-making. Indicators are identified as being a tool for informing and strengthening the institutional framework for sustainable development and including measurable objectives into policies and plans (United Nations 2002a; United Nations 2002d). A key outcome was the UN CSD indicator set, explored further in this chapter.

2.3.3 The United Nations Development Programme (UNDP) – Human Development Report

The UNDP has been publishing its Human Development Reports since 1990. The reports are a guide to human development issues using aggregated indicators as a means to convey trends.

The reports contain indicators that compare the relative levels of human development of over 175 countries (UNDP 2001). Starting in 1990, the reports used traditional social and economic indicators[60] to measure the state of human development in selected countries. Early recognition came in the human development reports that a healthy society was an essential component of sustainable development, and that economic growth (and poverty) were linked to environmental protection (and degradation).

The Human Development Report series introduced the human development index (HDI). The index combines life expectancy, educational attainment and income indicators to give a composite measure of human development. The indicators that are measured for these criteria are life expectancy, educational attainment and adjusted income per capita in purchasing power in US Dollars (UNDP 2001). The HDI is an average for each country and does not reveal disparities among different social, economic or regional groups.[61] The HDI is the primary index used in assessing human development, but other indices have been distilled from the HDI. These include the Human Poverty Index (HPI), the Gender Related Development Index (GDI), and the Gender Empowerment Measure (GEM)[62]. These measurements combine to assess the state and trends of human development for over 160 countries.

The Human Development Reports do not attempt to make a measure concerning sustainability itself, but rather focus on measuring a core component of the sustainability equation – just, fair and equitable human development. The reports clearly articulate that human development is a vital component of a sustainable society and leads to positive environmental and socio-economic outcomes.

2.3.4 OECD initiatives

The influence of the OECD upon the development of indicators at an international and national level has been immense, with frameworks and methodologies exported to programs at all levels,

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[60] Selected traditional indicators used in measuring ‘progress’ were poverty, education, nutrition, health, gender, income, and income distribution. These were used in the development of the *human development index.*

[61] For selected countries with appropriate data, separate HDI have been prepared to account for gender, income, and regional differences. HDI have been prepared over a time series of earlier years, so that change in human development can be tracked over time. See the Human Development Reports on (UNDP 2001).

[62] For a detailed description of the construction and use of all the indicators and associated indices see the latest HDR (UNDP 2001).

including adoption by several national governments.[63] The OECD has developed indicators under the environmental, economic and social dimensions of sustainability and developed a comprehensive framework for their organisation.

The OECD has set a rigorous policy agenda for sustainable development, focusing its work on the integration of environmental considerations into socio-economic decisions (OECD 2001a; OECD 2001b). A key program that has influenced indicator development worldwide is the initiative on environmental indicators (OECD 2001b; OECD 2001c). The initial commitment to environmental indicators occurred at the 1991 meeting of Environment Ministers of OECD countries, committing to a program of assessing member countries environmental performance (OECD 1997A).

The Environmental Performance Review program was established in 1992, its goal was to help member and selected non-member countries to improve performance in environmental management[64] (OECD 1997A). A preliminary set of indicators was established in 1991 and reviewed in 1993 where the conceptual framework and core indicators were developed[65]. These indicators have been reviewed every two years and used in performance assessment (OECD 2001d). This core set is envisaged not only as a tool for measuring environmental performance, but also as an approach for reporting on sustainable development. Reporting has occurred across a wide range of issues including climate change, ozone depletion, acidification, toxic contamination, urban environment quality, biodiversity landscapes and waste. In addition resource issues have been evaluated and have included water resources, forest resources, fish resources, and land resources (OECD 1993b; OECD 2001d).

The indicators in the OCED program are organised into a framework known as the Pressure State Response (PSR) model. The PSR model (Figure 8) was developed as a means to organise multiple indicators and address environmental issues in a logical structured manner. It was derived from the stress-response framework for ecosystems developed by Friend and Rapport in 1979 (Friend 1979). This framework has been exported to many initiatives around the world as a useful way of structuring indicator information and assessments. [66] The PSR model is based on the notion of causality: human activities result in an array of *pressures* upon the environment,

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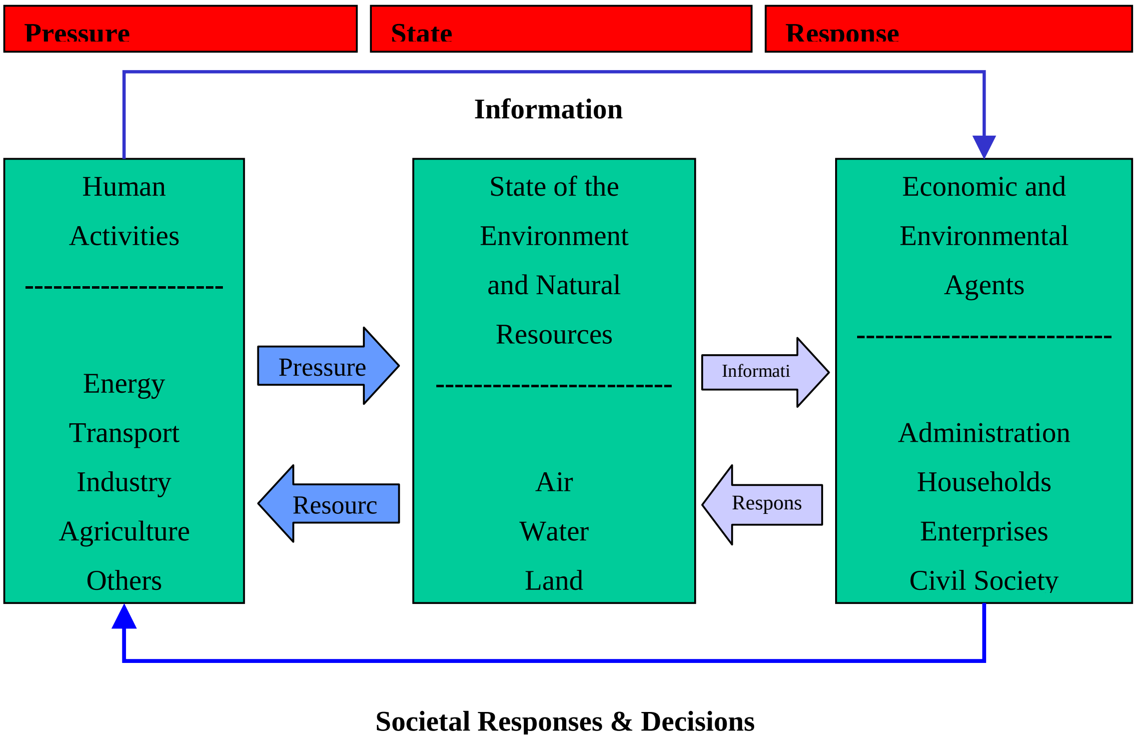
[63] The OECD Pressure, State, Response model, that was developed the early 1990's has been used and adapted by national governments such as New Zealand and Canada in addition to non member countries in central and eastern Europe (OECD 1993A). See below for expansion.
[64] A detailed description of the Environmental Performance process is provided in (OECD 1997A).
[65] The core set of indicators can be viewed at (OECD 1993B).
[66] See the use of the PSR model in the case studies.

which derives natural resources for societal use (OECD 1993B; Moldan 1997). The pressures alter the quantity and quality, or the *state* of natural resources and affect processes in the physical and ecological environment. The pressures that affect the state of the environment result in a societal *response* in the form of environmental, economic and sectoral polices (OECD 1994; Moldan 1997). The response action forms a feedback link that affects the pressures. (OECD 1997a) states how this process forms a similar parallel to the steps taken in the policy cycle, that of problem perception, policy formation, monitoring and evaluation and hence is a useful structure for ordering information and assessing sustainability issues.

Figure 8. The Pressure State Response Model (OECD 2001a).



The PSR framework distinguishes three types of indicators:

- **Pressure Indicators** represent the pressures from human activities upon the environment. These indicators can be further subdivided into direct and indirect pressures. Direct pressures refer to pressures that are directly exerted upon the environment (e.g. emissions from pollution or the consumption of natural resources) whilst indirect pressures refer to broader, background pressures that influence and drive human activity.

- **State Indicators** reflect the status of components of the environment over time, and the quality and quantity of resources. They are designed to be decoupled from environmental pressures, that is, the indicator should reflect the physical state of the environment and not the pressure upon it.
- **Response indicators** represent the response from society to a particular environmental issue, such as a response from an agency, or a monitoring or action program in relation to the issue. Response indicators are the least developed in the framework and require further work (OECD 1993a; OECD 1994; OECD 2001b).

The PSR framework implies causality between parameters: pressures affect the state, which results in a societal response. This link can be useful in raising awareness about environmental relationships and can be used in a policy context as it organises the indicator information into a structured framework. The PSR model has however, several limitations. Because it has ‘cause and effect’ linkages, it can neglect the systemic and dynamic nature of environmental processes, and oversimplify complex issues (Bossel 1999). The danger of interpreting the link between the PSR variables as a linear relationship is evident **-** seeing the pressure as the cause, the state as the effect and the response as a feedback regulator or effect (Moldan 1997). The initial PSR model could lead to distortions in identifying the true cause of the problem.

Further research is required to identify system relationships and avoid drawing invalid references from an oversimplified view of an issue. Indicator systems are not replacements for scientific research and modelling on complex issues, rather they are an additional tool that can aid in policy development and decision-making (Hardi et al 1997; Higgins 2001; Hanson 2003). The PSR model has emerged as a dominant force in indicator frameworks, and is used by several national and international institutions for assessing sustainability. Its simplified and systematic approach has enabled the PSR to be easily adopted in reporting despite the danger in using a linear cause and effect approach.

2.3.5 United Nations Environment Program (UNEP) and GEO Reports.

In 1993 UNEP commissioned a report into the development of indicator science. It was an influential milestone in the development of sustainability indicators, bringing together information from national, regional and international jurisdictions and addressing key issues such as data and aggregation. The report suggested a stress-response conceptual framework for the selection, development, and analysis of indicators under three related sub-systems: (1) the human population, (2) production, consumption and technology; and (3) the environment (Bakkes et al 1994).

The initiative focused on PSR type approaches and integrated methodologies across the range of pressure, state and response type criteria. This improvement of information across the matrix of the issue would be enhanced by reporting frameworks that stress the linkages between environmental and socio-economic aspects of sustainability, poorly covered at the time (Bakkes et al 1994). A key issue was the use of indicator information, referring that characteristics of systems have been determined by information producers rather than by users (Bakkes et al 1994). Furthermore effort was required to address information issues in developing countries and increase the capacity for these countries to construct and use indicators. This issue is still a priority today as it was in 1994.

In 1997, UNEP pioneered the development of the Global Environmental Outlook (GEO) reports (UNEP 1997). The UNEP GEO project was initiated in response to the environmental reporting requirements of Agenda 21 and to a UNEP Council decision of May 1995 that requested the production of a comprehensive global state of the environment report (UNEP 2003). The GEO project addresses five key questions (UNEP 2003):

- What are the major regional and global environmental problems, both current and emerging?
- What are the major demographic, social, and economic driving forces behind the observed problems and trends?
- Where are we heading if we continue doing "business as usual"?
- Where do we want to be heading?
- What is being done to address environmental concerns and what can be done in the future to move forward on the path of sustainable development?

GEO reports focus on integrated reporting with environmental issues coupled with socio-economic developments and provide policy advice and evaluation of options for governments on key environmental issues. The reporting and assessment process aims to be cross-sectoral and participatory encouraging the building of consensus. Outputs from the GEO process include a state of the environment report, a data portal and advice for international policy, planning and resource allocation (UNEP 2003).

The GEO reports, published in 1997, 2000, and 2002 (the latest on the 30th anniversary of the Stockholm Declaration) represent a growing effort at indicator based international environmental reporting. The process has increasingly moved towards sustainability reporting with the addition of socio-economic indicators and integrated reporting frameworks (UNEP 2002). In addition, the GEO reports have taken the further step of linking objectives to action by making policy recommendations on the basis of the results and focusing on action decision-making on international environmental issues.

2.3.6 World Bank initiatives

The World Bank has played a significant role in the development of indicators since 1995. It uses indicators in environmental and development assessment and contributes to measurement and accounting methods (World Bank 1997b) The World Development Indicators (WDI) has been an ongoing initiative, released in annual reports since 1998 (Chesson 2000). The reports contain approximately 600 indicators organised under the following themes (World Bank 2002):

- World view
- People
- Environment
- Economy
- States and markets
- Global links

The WDI report focuses on 148 economies with basic indicators for a further 62 economies (World Bank 2002). Each grouping above is sub-divided into a thematic classification, for example, environment is subdivided into land-use, agriculture, biodiversity and protected areas, water pollution, energy, urbanisation and environments, air pollution, government and genuine savings (World Bank 2002). The groupings are loosely based on the pressure-state-response model. From the WDI the World Bank releases annual data and analysis (World Bank 2001) and has contributed to sustainability based accounting systems that integrate environmental and economic concerns (World Bank 1997a).[67] In addition to the WDI, the World Bank produces

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[67] (World Bank 1997a) details new aggregate indicators that link the macro economy and the environment. The indicator called *genuine saving* has been generated to accurately reflect the wealth of nations, taking into account the depreciation of produced assets, the depletion of natural resources, investments in human capital, and the value of global damages from carbon emissions.

environmental performance indicators that are used to monitor project performance of investment projects (World Bank 2002). These indicators specifically refer to measurement of performance of projects and operate at a project scale. This is linked to a recent program called ‘Indicators on the Web’ (World Bank 2002). This project essentially gathers information on themes such as resources, and pollution control at a project and national level that task managers can use in assessing project impacts.

2.3.7 The Scientific Committee on Problems of the Environment (SCOPE)

SCOPE is a non-government authority that advances knowledge on human and environment interactions (Garcia 2000). In 1994 SCOPE was influential in providing advice for social, economic and environmental indicators, integrating national level indicators and facilitating dialogue between data users and producers (Dahl 2000; Garcia 2000). A series of workshops in 1995 provided information that tackled many scientific issues pertaining to indicators, especially issues of data, aggregation methods and visualisation (SCOPE 1995; Moldan 1997). This included key outcomes meetings between the Commission on Sustainable Development (CSD), United Nations Environment Program (UNEP) and key governments from developing nations who expressed concern at the proposed development of indicators (SCOPE 1995). The resulting report in 1997 was influential in assisting the technical and political development of indicators and established the Commission on Sustainable Development work program (SCOPE 1995; Dahl 2000).

2.3.8 United Nations Commission on Sustainable Development (CSD)

The CSD work program on sustainability indicators represents the peak international effort to develop indicators as tools for sustainable development. The program was an intensive effort of collaboration between governments, international organisations, academic institutions and NGOs aimed at establishing a useable national set of indicators for sustainability assessment (Dahl 2000).

In 1995 CSD initiated a five-year work program on Indicators of Sustainable Development as a way to measure progress in implementing Agenda 21 (Garcia 2000; UN Department of Economic and Social Affairs 2001). The objective of the program was to make indicators of sustainability available at the national level by defining them, elaborating methodologies, and providing training and capacity development. It was proposed that the indicators could be simultaneously used in national policy making and international reporting (UN Department of

Economic and Social Affairs 2001). Phase 1 of the initiative commenced in 1995 and focused on developing methodologies for the 134 indicators (Garcia 2000). The method sheets provide information on the indicator, its decision relevance, measurement methods, data availability and responsible agency (UN Department of Economic and Social Affairs 2001). Phase 2 of the initiative commenced in 1996 and focused on training, capacity building, and the national testing of the indicator set. Participating governments were encouraged to pilot test and experiment with the indicator set over 2 years. Phase 3 of the initiative commenced in 1999 and focused on the evaluation of the testing results, the compilation of a database, and the finalisation of the working list of indicators and the reporting framework (Garcia 2000; UN Department of Economic and Social Affairs 2001).

The discussion of indicator frameworks was a priority under the CSD initiative. Early work categorised the indicators under the chapter headings of Agenda 21 and under the four dimensions of sustainable development – environmental, social, economic, and institutional. Within these categories, the indicators were further classified according to a variant of the PSR model called driving force-state-response (DSR) model (UN Department of Economic and Social Affairs 2001). Under this framework an initial list of 134 indicators were identified for development and testing by candidate countries. After the testing phase, the DSR model was abandoned in favour of a thematic organising framework (UN Department of Economic and Social Affairs 2001). This shift occurred due to the experiences of the testing countries that recommended that the framework reflect an emphasis on policy issues or themes related to sustainable development, that there be balance and comprehensiveness across the sustainability spectrum, and that the indicators be narrowed to a core set that reflect common issues and priorities (UN Department of Economic and Social Affairs 2001). As a result, the final thematic framework consisted of 15 major themes, 38 sub-themes, and 58 core indicators (Table 2 below). The emphasis has been placed on an indicator system that delivers pragmatic conceptually sound indicators for decision making, representative of an international consensus, and covers the broad themes of sustainable development. This CSD program continues to report at an international level and has been a driving force for indicator development. The framework, themes and indicators are summarised in Table 2 below.

Table 2. The United Nations CSD Indicator Set (UN Department of Economic and Social Affairs 2001)

	Theme	Sub Theme	Indicator
Social	Equity	Poverty	% of population below poverty line
		Gender equality	Ratio of average female wage to male
	Health	Nutritional status	Status of children
		Mortality	Mortality under 5 y.o.
		Sanitation	% populatoin with adequate sewage disposal
		Drinking water	Population access to safe water
		Healthcare delivery	% of population with access to primary health care Child immunization Contraceptive prevalence rate
	Education	Education level	Children reaching Grade 5 of primary ed. Adult secondary ed level
		Literacy	Adult literacy rate
	Housing	Living Conditions	Floor Area per person
	Security	Crime	Number of recorded crimes per 100 000 pop.
	Population	Population change	Population growth rate Population of urban formal and informal settlements.
Environment	Atmosphere	Climate Change	Emission of greenhouse gases
		Ozone Depletion	Consumption of Ozone depleting substances
		Air quality	Ambient concentration of pullutants in urban areas
	Land	Agriculture	Arable and permanent crop land area Fertiliser Use Pesticide use
		Forests	Forest area as % of land area Wood harvesting intensity
		Desertification	Land area affected by desertification
		Urbanisation	Area of formal and informal settlements
	Oceans & Coasts	Coastal Zone	Algae concentration in coastal waters % of total population living in coastal areas
		Fisheries	Annual catch by major species
	Fresh water	Water quantity	Annual % withdrawal of ground and surface water
		Water quality	BOD in water bodies
	Biodiversity	Ecosystem	Area of selected key ecosystems Protected areas as a % total area.
		Species	Abundance of key selected species.
Economic	Economic structure	Economic performance	GDP per capita
		Trade	Balance of trade in goods and services
		Financial status	Debt to GNP ratio Total ODA given or received as & of GNP
	Consumption patterns	Material consumption	Intensity of material use
		Energy use	Annual energy consumption per capita Share of consumption of renewable energy resources Intensity of energy use
		Waste generation	Generation of municipal and industrial solid waste Generation of hazardous waste Generation of radioactive waste Recycling and usage
		Transportation	Distance travelled per capita by mode of transport.
Institutional	Institutional framework	Implementation of ESD	National SD strategy
		International cooperation	Implementation of ratified global agreements
		Information access	Number of internet subscribers per 1000 participants
		Communication	Main telephone lines per 1000 inhabitants
	Institutional capacity	Science and Technology	Expediture on R&D as a % of GDP
		Disaster preparedness	Economic and human loss due to natural disasters.

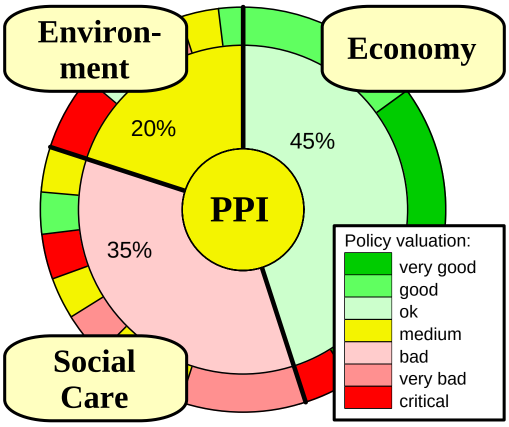
2.3.9 The International Institute for Sustainable Development (IISD)

The IISD is a leading non-government authority on, and strong advocate for, the development of indicators. The IISD has several program areas of interest in relation to sustainability, including a dedicated program for assessment and measurement (IISD 2001). The IISD has been involved in indicator and policy development since 1995. It has an objective of making significant contributions to indicator theory and practice and maintains a detailed compendium on indicator initiatives (IISD 2001). An important initiative coming out of the IISD is the Consulting Group on Sustainable Development Indicators (CGSDI) and the Dashboard model.

The CGSDI formed as an outcome of the SCOPE project in 1996 (IISD 2001)and takes an innovative departure from traditional indicator research, focusing on the development of indices and visualisation of the results (Dahl 2000). The program on aggregated indices states that its goal is to develop a 'super' aggregate of environmental, social, and economic indicators on par with the GDP (CGSDI 2002). While this is an extremely complex task, it acts as a useful policy and media focus for highlighting issues of sustainable development.

The visualisation of indicators is an important but generally neglected stream of research. The CGSDI is investigating the use of several models in the visualisation process, with a focus on an innovative approach, the Dashboard of Sustainability. The 'Dashboard' is a visualisation tool that converts indicator data into standardised scores and presents them in the form of a dashboard or instrument panel (CGSDI 2002). A range of colours from green (signalling a desirable trend) to red (signalling an undesirable trend) for each indicator and its aggregate, signals performance to decision makers (Figure 9). The outer circle represents the individual indicators within a policy field; these scores are aggregated to form an index for the overall policy field and for an overall sustainability index (or the Policy Performance Index) (Jesinghaus 1999).

Figure 9. The Dashboard approach based on a sustainability assessment (adapted from Jessinghaus 2003).



The tool enables improved communication of indicator data and facilitates the presentation of aggregated indices to the public and decision makers (Jesinghaus 1999). It recognises the need to simplify large lists of complex measures into simplified (but not simpler) aggregated measures using visualisation strategies. The Dashboard has been applied to the UNCSD program, comparing 10 years of progress from the 1992 Rio summit to the 2002 Johannesburg summit (CGSDI 2002).

2.3.10 Evolving methods and approaches

The development of a variety of measurement and policy initiatives at an international level has provided a critical conceptual backdrop to indicator science. Many initiatives at the national and local scales have based their frameworks on international systems, including specific indicators and processes of measurement. The impetus for indicator development has come primarily from the international level, with international agreements such as Agenda 21 setting the framework and being the driving force for action on sustainability reporting and assessment.

The rapid assimilation of indicator programs at the national, local and sectoral level has been significant. Many countries, based on their international Agenda 21 commitments, have developed reporting strategies for sustainability that link to major government policies. However the coordination of these systems amongst competing users, the development of indicator measures and monitoring regimes and their actual use in management decision-making still remain significant challenges. The challenge for indicator systems has emerged as a primary focus for specific sectors, which are examining in detail these particular problems within their contexts. The international developments in indicator science have remained an important backdrop and technical source for conceptual and practical application of the concept to specific sectors.

The next section examines two natural resource sectors that have driven the development of indicators – forestry and fisheries. A brief overview of the international development of forestry indicators is examined in 2.4, while 2.5 investigates in detail the development and challenges of fisheries indicator systems – the focus of this thesis.

2.4 Sustainability Indicators in Forestry – An Overview

The international development of sustainability indicators in the forestry sector parallels in many ways the same developments in fisheries. UNCED, held in 1992, set the guiding principles for sustainable forest management as a contribution towards sustainable development (FAO 2003c). UNCED established two key outcomes for sustainable forestry: the "Forest Principles" and Chapter 11 of Agenda 21, enshrining in policy the commitments made by countries in the forestry domain (FAO 2003b). Principle 2b of the Forest Principles highlights the nature of the agreement (FAO 2003a, 2003c):

> "*Forest resources and forest lands should be sustainably managed to meet the social, economical, ecological, cultural and spiritual needs of present and future generations.*"

Chapter 11 of Agenda 21 specified the need for improved measures relating to forest sustainability. It highlighted the need of "formulating scientifically sound criteria and guidelines for the management, conservation and sustainable development of all types of forests", the start of an international drive towards indicators (FAO 2003b). It should be noted that several countries considered the notion of sustainable forest management before the onset of UNCED. In particular, and in a similar line with fisheries management, the notion of sustainable yield was common practice for a century of forest management. In addition practices often considered the ecological impacts of forestry on watersheds and soil and water practices (FAO 2003d).

The aim of criteria and indicators is to promote improved forest management practices over time, and to further the development of a healthier and more productive forest estate, taking into consideration the social, economic, environmental, cultural and spiritual needs of stakeholders.

The FAO process for determining criteria and indicators for forestry (FAO 2003a) identified the role of the measures:

- **Criteria** define the elements against which sustainability is assessed, with due consideration paid to the productive, protective and social roles of forests and forest ecosystems. Each criterion relates to a key element of sustainability, and may be described by one or more indicators.

- **Indicators** are parameters which can be measured and correspond to a particular criterion. They measure and help monitor the status and changes of forests in quantitative, qualitative and descriptive terms that reflect forest values as seen by those who defined each criterion.

This process has resulted in an international, national and sub-national push for the development of relevant criteria and indicators, met with varying degrees of success. At the international level, criteria and indicators help countries to prepare consistent national reports for international organisations, UN conventions and legally-binding agreements related to forests. At the national level the measures contribute to monitoring the performance of national forest programs and providing a framework for strategic planning, monitoring and certification. Forest-level indicators provide a management level benchmark for the sustainable forest activities.

At the international level, nine eco-regional and regional forestry initiatives involving 145 countries and 97.5% of the worlds forest area, have been established since 1992. These initiatives have been designed to develop and apply criteria and indicators to forestry practices. The initiatives include (FAO 2003d):

- The 'Helsinki Process' which focuses on the development of criteria and indicators for European boreal, temperate and Mediterranean-type forests. The European countries have agreed upon six common criteria, 27 quantitative indicators, and a number of descriptive indicators for sustainable forest management;

- The 'Montreal Process' for boreal forests outside of Europe. The countries have agreed on a set of seven, non-legally binding criteria and 67 indicators for sustainable forest management;

- the 'Tarapoto Proposal of Criteria and Indicators for Sustainability of the Amazon Forest'. Seven criteria and 47 indicators were identified and proposed for national level implementation in the eight participating countries. Criteria and indicators were also identified for the forest management unit level (an additional four criteria and 22 indicators) and for the global level (one additional criterion and seven indicators);

• The UNEP/FAO Expert Meeting on Criteria and Indicators for Sustainable Forest Management in Dry-Zone Africa.. Identified seven criteria and 47 indicators;

• the FAO/UNEP Expert Meeting on Criteria and Indicators for Sustainable Forest Management in the Near East Region. Seven criteria and 65 indicators were proposed;

• an Expert Meeting on Criteria and Indicators for Sustainable Forest Management in Central America. Identified 4 criteria and 40 indicators for the regional level, and 8 criteria and 52 indicators for the national level.

While each eco-region processes differs in specific content or structure, all of them centre around seven globally agreed thematic areas (Counsell & Loraas, 2002; FAO 2003a, 2003b):

- extent of forest resources,
- biological diversity,
- forest health and vitality,
- protective functions of forests,
- productive functions of forests,
- socio-economic functions,
- legal policy and institutional framework.

The development of forestry sustainability indicator programs has intensified discussion on sustainable forest management, and increased exchange of information and experience between countries and organisations. These initiatives have paralleled the development of fisheries indicator programs at international, national and the fishery management level, and have faced the same complexities over the development of relevant and consensual frameworks, criteria and indicators at all scales. In addition, both sectors have been investigating the implementation of ecosystem-based management into the practical realities of day-to-day management processes.

Another key parallel of the forestry and fisheries indicator development has been the growth of indicator based certification movements in the forestry and fisheries fields. The Forest Stewardship Council and Marine Stewardship Council have evolved to use indicators to certify sustainable practices and engage the use of market forces to encourage the development of sustainable industries (Forest Stewardship Council 2003; MSC 2003). Both movements have faced significant and similar implementation issues over independent certification methodologies and the application of sustainability principles and criteria (Counsell & Loraas 2002).[68] The Marine Stewardship Council is explored in detail as a case study in this thesis.

2.5 Towards Indicators for Fisheries Sustainability.

Chapter 1 noted that to address sustainability concerns, fisheries were moving towards ecosystem-based management and precautionary approaches. Identified as a tool to achieve these goals and operationalise the objectives set by sustainability, the fishing sector has moved to apply indicator systems. Despite a great deal of literature on sustainability and the management of fisheries in general, there is little guidance on the specific development of sustainability indicator systems for fisheries (Garcia 2000). This is complemented by a lack of detailed case studies that describe and analyse fisheries institutions using indicators as implementing tools. The research on indicators in other sectors can provide a useful starting point for a fishery based framework, but ultimately fisheries systems have unique characteristics that must be accounted for to assess their sustainability. This thesis begins to address this lack of information by analysing several cases of indicator usage across a variety of jurisdictions and provides a framework for indicator development.

2.5.1 Sustainability and Fisheries Management

Ecosystem health and integrity, as the foundation of sustainable fisheries, has emerged as a key objective within management in the form of ecosystem-based management (Pitcher 2000; Kaye 2001). This raises a potentially complex and confusing range of additional issues to be considered in management decisions, in reporting on status, and in assessing performance (Sainsbury, 2003). Precautionary approaches have also been an important part of fisheries sustainability with tools developed to address the inherent uncertainty in fisheries management

[68] The development of the Forest Stewardship Council Principles and Criteria, and a critique of its performance can be found in: Counsell & Loraas (2002); Forest Certification Resource Centre (2003), Forest Stewardship Council (2003), and Forest Stewardship Council (2003).

and science (Essington 2001). An increasing awareness of social, community and economic concerns in the fisheries equation, especially the role of fisheries in maintaining coastal communities and their role in food security, is providing demands for new information and reporting (Bowen 1996; Lane 1996). Managing fisheries for sustainability is a multi-dimensional and multi-level activity that must report on a wider range of considerations than the survival of stocks and the immediate fishery concern. This process needs new and improved information, and hence indicators, on the dimensions beyond fish stocks and activity.

2.5.2 Fisheries specific indicator systems

The international dialogue on the sustainability of fisheries combined with the experience of indicators in other sectors, has led to the development of fisheries specific indicator systems. It is clear that new information and methods for reporting within a decision-making context are required. Several authors note [69] that the issue of sustainability within fisheries has many dimensions and complexities at several scales - made more complex with the emerging ecosystem-based and precautionary requirements. (Garcia 2000) notes that sustainability can be considered at the stock level, the species assemblage, the large marine ecosystem, the fisheries sector, the EEZ, the national economy, the region or the entire ocean. The indicator system is adapted to a particular jurisdiction and its reporting and assessment requirements.

2.5.3 Relationships between broad and specific fishery indicators.

Indicators generally fall into two camps: broad based and sector specific (Dhakal & Hidefumi 2003). Broad based indicators assess national performance on the environment [70] and are moving towards integrated assessments (from the UNCSD, OECD, UNEP and national governments). These systems contain measurements of important environmental issues, macro economic factors and social assessments. The systems often have limited or simplified indicators for reporting on marine issues but are designed for general communication to the government and public. For reporting and policy dialogue at national / international scales this can be adequate, but for detailed fishery management decisions a simplified indicator will not reflect the complex relationships within the marine system. The broader systems have attempted to include (at varying degrees of success) socio-economic objectives and indicators, and area of real priority

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[69] See Garcia 1996; Botsford 1997; FAO 1999; Fisheries 1999; Garcia *et al* 2000;
Arbour *et al* 2001; Fletcher *et al* 2001; and Sainsbury, 2003.

[70] The indicators usually form a part of State of the Environment type approaches.

within the field. These measures however, are fairly general in nature, and are usually related to macro-type measures of an economic or social dimension. Setting indicators that relate to specific fisheries systems and their communities is a difficult and challenging prospect.

Sector specific indicators have generally reported at the fishery level to remain as practical as possible and remain relevant to managers and fishers (Garcia 2000). Indicator frameworks combine different sustainability dimensions with combinations of indicators based on the objectives of the assessment and the users of the information. As the broader national and international reporting systems use simplified indicators to communicate generalised fishery information, complex sector specific systems are poorly integrated with these broader level reporting initiatives. The fisheries specific systems have tended to focus on the biological / ecological aspects of sustainability and have occasionally crossed into the management related aspects of the fishery. The full inclusion of socio-economic measures has been sparse – and directly related to the lack of indicator suitable information for fishery specific socio-economic concerns.

There is an obvious need for increased integration between detailed sector reporting and broader national and international arrangements. Broader reporting has a lack of (or simplified) marine indicators while sectoral reporting requires increased integration. As research on the development of aggregated indices progresses, the inclusion of meaningful indices on fisheries sustainability issues can be expected to appear at higher scales of operation. This incremental development will be a result of the increasing capacity within the fisheries sector to report on sustainability issues and incorporate the results into decision-making regimes.

2.5.4 Fisheries Indicator Frameworks: An example from FAO

There are literally dozens of approaches that can be used to establish an indictor set for a fishery. The first step is to establish a reporting framework as a convenient and effective way to organise the indicators. Frameworks have followed the approaches taken in the international and national arena, such as the PSR model, the FAO definition of sustainable development and thematically driven frameworks. The framework, as a first step, breaks down the conceptual notion of sustainability into structural dimensions that enable the establishment of more specific criteria. Dimensions can be:

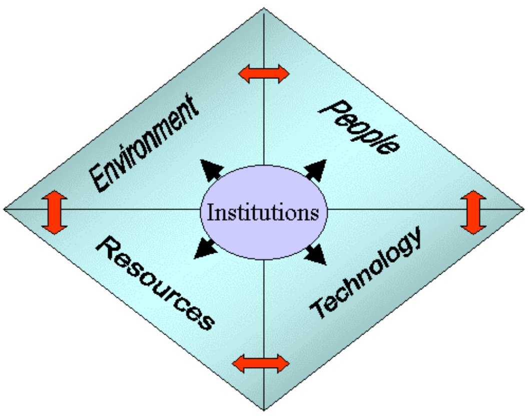
- The broad themes of sustainability, eg. social, economic, environmental and institutional;
- States, pressures and responses as exemplified in the PSR model;

- Theme or issues based, eg. management, aquaculture, harvest, trade etc.

The choice of a particular framework for assessing a fishery may depend on a particular policy priority (eg. expanding ecosystem-based management) or relate to similar experiences and frameworks that have been used in the past. Generally in practice, the choice of the framework is not critical as long as it meets the scope of the assessment. FAO notes that in many cases, different frameworks will lead to the adoption of the same or similar sets of indicators, but provide different perspectives on examining sustainability (FAO 1999a).

The FAO definition of sustainable development and the Code of Conduct for Responsible Fisheries provide an example of a framework for indicators. The FAO definition was developed in 1989 [71] and has been identified as the basis of a framework for indicators (FAO 1999a; Garcia 2000). The dimensions of the FAO definition are displayed below in Figure 10. Sustainability is divided into interacting environmental and human components. The resources are a subset of the environment, while technology is a subset of people. All spheres interact through institutions. The environment and its resources must be conserved, while people and technology must be satisfied and guided through management (FAO 1999a). In terms of measuring fisheries sustainability, the FAO definition would need to define a structured set of fishery-relevant criteria, which are further divided into measurable indicators.

Figure 10. Schematic of the FAO sustainability framework (FAO 1999A).



[71] FAO (1999) defined sustainable development as: The management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment of continued satisfaction of human needs for present and future generations. Such sustainable development conserves land, water, plants, and animal genetic resources, is environmentally non-degrading, technologically appropriate, economically viable, and socially acceptable.

The FAO definition is a generalist approach that can apply to a variety of sectors. Despite being adequate as a generalised high-level framework, it fails to provide a direct focus for issues that are relevant for fisheries. The framework needs to be adapted and structured towards a fisheries focus to be relevant. (Garcia 2000) has developed a hybrid framework addressing this issue by merging the FAO definition with the FAO Code of Conduct for Responsible Fisheries (see below).

The Code of Conduct for Responsible Fisheries is a practical guide to the implementation of sustainable fisheries. The Code translates the FAO definition of sustainable development into a detailed set of operational guidelines. It goes beyond harvesting operations and includes sections on fisheries management, fishing operations, aquaculture development, coastal area management, post harvest practices and trade, and research (FAO 1995). An operational article addresses each of these topics with specific actions for each sub sector. As a non-binding instrument the code has gained wide support across the members of FAO in relation to its goals of providing a practical foundation to establish sustainable fisheries (FAO 1999a; Garcia 2000).

(Garcia 2000) notes that the Code can be interpreted as a conceptual framework for indicators, focusing on implementation as opposed to reporting. By identifying the links between the FAO sustainability definition and the Code of Conduct, a framework can be identified that combines objectives with implementation strategies. (Garcia 2000) has identified principles, sub-principles and criteria for assessing a fishery (Table 3 below). This structure would be the basis of organising indicators and used as the basis for assessing countries implementation of the Code of Conduct (and therefore if a fishery is moving towards sustainability). Combining the conceptual and the practical provide a powerful tool for assessing sustainability.

Different levels of the framework could be used for different policy needs, for example, reporting on the environment or economic status, or assessing different stages of the policy cycle. Within each indicator system it is important that the framework is aligned to the policy requirement, and suitable dimensions, criteria, objectives and indicators are structured in a coherent fashion for use in decisions and analysis. This example highlights a framework that provides a format for reporting on fisheries issues at national and sub national scales.

Table 3. The FAO Code of Conduct and FAO Sustainability Indicator Framework

FAO Definition		Code of Conduct
Dimension	**Sub Principles**	**Criteria**
1.Maintain the resource and environment system.	1.1. Maintain the target resource at renewal capacity under ecologically acceptable conditions.	State of the target resources, quality, diversity and availability of target resource Management measures
	1.2 Maintain (enhance) the environment.	State of the ecosystem, environment, biodiversity, and population structure Management measures Research
2. Satisfy human, economic and social needs, now and in the future.	2.1 Satisfy human needs (safety and quality of food, employment)	Protection of small-scale fisheries interests. Working and living conditions Access to technology Food security
	2.2 Ensure long-term economic viability	Economic conditions conducive to sustainability Value adding Trade standards
3. Put in place an effective management system.	3.1 Objectives of management explicit & adequate	Aiming at resource conservation and satisfaction of human needs at appropriate scales
	3.2 Establish management institutions that provide for, and lead to, effective governance	Management plans Research plans Integrated coastal plans Participation mechanisms Decision making processes Legal framework Information Implementation Process Precautionary approaches Performance
	3.3 Technology compatible with resource and environment maintenance.	Captivity, selectivity, impacts, waste, pollution.

Adapted from (Garcia 2000)

2.5.5 Criteria and Indicators used in fisheries sustainability.

The development of a framework is the first step in developing an indicator system. The dimensions are subdivided into fisheries relevant criteria that represent the properties that will be affected by sustainable development. The process is one of breaking down conceptual objectives to an operational level, so that specific measuring parameters, i.e. indicators, can be established. The indicator measurement can explain the state or behaviour of a criterion and monitor the conditions in the fisheries sector (Garcia & Staples 2000). Indicators can therefore be used to assess performance in regards to different components of the fishery system: the target species, associated and dependent species, the ecosystem, socio-economic conditions and governance considerations (Charles et al 2002). Table 4, below, displays examples of potential indicators under fisheries criteria and dimensions. The list is not exhaustive, but presents some of the commonly used measures.

It is at this stage of development that objectives are set for the system. The objectives are dependent on the scale being considered (eg. food security will set different objectives at the local and national levels). Objectives can be distilled from international agreements, national policies on sustainability, specific fisheries sector policies, management plans, or legislation and will assist in the selection of a specific indicator. Some objectives may be clearly defined, but others may require some innovation on the part of the practitioners and may require substantial debate over the desired goal for the criteria and indicator. The setting of objectives relates to establishing reference points allowing for concise interpretation of the trend of the indicator and a measure of its performance. The key issue is that higher-level objectives identified for the fishery can be measured by meaningful indicators, and the system is structured to be pragmatic for users and effective as a decision tool. There is no standardised approach to measuring sustainability via an indicator system – success must be measured by the quality of the outputs from the system and its relevance to decision-makers and stakeholders.

Indicators aim to support effective decision-making through the spectrum of activities that is the fisheries management process. This includes the internal management processes and the external assessment and observation by stakeholders and the community. They assist decision-making in problem identification, objective setting, and identification of gaps in research and data, monitoring and performance assessment (FAO 1999a; Garcia 2000). Indicators promote debate about the complexities involved in developing sustainability policy and can act as a lever for accountability and transparency in decision-making (Bell & Morse 1999). This poses a significant challenge to organisations undertaking indicator initiatives as it highlights the need to build consensus on the indicators themselves and to build information systems that collect and use the data for the indicators.

Table 4. Dimensions criteria and indicators for Fisheries sustainability.

Dimension	Criteria	Indicator
Environment	Abundance of target Species	Biomass estimate, level of spawning biomass relative to unfished level.
	Catch structure	Frequency-length distribution model
	Direct impacts of fishing gear on non-target species	Seabird catches per 1000 hooks in line fishery.
	Indirect impacts of fishing gear on non-target species	Ghost fishing: discarded gear type and quantity
	Fishing pressure	Level of catch per species per area
	Ecosystem structure	Trophic level, food web structure
	Protected areas	Percentage of protected areas by type
	Impact of gear on critical habitat	Extent of trawling
Social	Demography and population	Demographical statistics
	Education	Level of education achieved
	Protein consumption	Consumption per capita
	Income distribution	GINI index, per capita earnings
	Safety at sea	Reported accidents, fatalities
Economic	Harvest Value	Fish product prices, profitability
	Fisheries contribution to GDP	Percentage contribution to GDP
	Exports	Exports vs. imports, export earnings as ratio of total
	Investment	Domestic investment in fleets & processing
	Subsidies	Direct and indirect subsidies
	Employment	Percentage employed in fishery by region / national
	Income	Income per capita vs. national average Net revenues
Governance	Compliance	Number of prosecutions
	Management	Fisheries covered by management plans
	Sustainable development strategy	Strategy present – objectives
	Resources	Long term funding
	International	Links to international instruments
	Voluntary best practice	Industry codes of practice

Adapted from FAO (1999), Fletcher et al (2002) and Des Clers & Nauen (2002).

Several examples exist of how indicators can be used in fisheries management:

- Assessment of a fishery against a national standard for environmental management;
- A means of performance assessment of a fishery against management guidelines, fisheries policy and/or legislation;
- A means of identifying data and knowledge gaps in the fishery and setting research priorities;
- A means of external assessment and participation by NGOs and the public and increasing the transparency and accountability of management decisions,
- As the basis of an eco-labelling program or trade certification;
- A means of including increased social and economic factors into decision making; and
- Tracking specific projects or initiatives such as a rehabilitation strategy.

In addition, indicators attempt to fulfil a specific critical function of improved communication to stakeholders in fisheries management. The use of complex models with demanding data requirements is an increasing approach in management, especially in light of ecosystem management approaches. The results and outputs of these models need to be communicated in a simple fashion to the relevant stakeholders and decision makers, especially the fishers themselves, if the process is to be successful. The rise of the co-management approach as a means of improving fisheries management can also benefit from the informing nature of indicators (Townsend 1995; DFO 1999a; DFO 1999a; Haward 1999). Keeping indicators simple enough to be readily understood and used by all stakeholders is a major challenge for all initiatives[72]. The tendency for indicators to become ‘bogged down’ in ongoing scientific debate can directly compromise their effectiveness as a tool to promote communication. The positive benefits of a well-researched indicator initiative are well known, however several important challenges remain to implement them successfully.

2.6 Challenges to fisheries indicators.

The implementation of indicator systems is a complex task requiring resources, cooperation and consensus. The challenges however, are not specific to fishery-type cases, rather they are generic

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[72] Garcia (2000) highlights in detail the technical aspects that fisheries indicators must meet including: policy relevance, scope, timeliness, accuracy and precision, scientific validity, consensual, legal foundation, specificity, multidimensionality, geographical resolution, dynamic and technical feasibility.

to indicator development across the board. Several challenges have been identified that remain significant hurdles for establishing an effective indicator system, described below.

2.6.1 Defining objectives and performance measures

The articulation of objectives is an essential component of indicator development, and one that takes resources and time. The objective defines the aim or goal of particular ‘criteria’ and places the indicator in this context.[73] The reference point then provides a function of a particular state of the indicator (in relation to the objective) that is desirable or requiring action.[74] Without succinct and clear objectives and targets to assess performance, the indicators have no direction and can be interpreted in many ways.

Objectives and targets have been difficult to define outside the sphere of the target species. Target species, as the basis of traditional management, have set and defined management objectives. For ecological and social criteria, objectives have remained elusive due to their interpretability based on the viewpoint of the stakeholder and the need for them to be extracted from within legislation and policy documents. This area of indicator development presents a unique challenge; it requires transparent and participative decision-making, consensus and action. Whilst defining objectives and targets has been an ongoing exercise, it represents an ongoing area of development within initiatives and one that is often neglected in practice. Objectives and targets for fisheries systems have been explored in detail by Chesson, (2000);Charles et al (2002), Garcia (2002) and Sainsbury (2003).

2.6.2 Issues of scale

Issues of scale are critical when considering the development of indicator systems. Fisheries and sustainability issues cut across a variety of scales and government jurisdictions (Dovers 2001) with ramifications for the identification and selection of indicators. Fisheries issues are relevant at several scales of activity, from the global, regional, national, sub-national and local levels - appropriate mechanisms must be developed to assess performance at each relevant scale. Complexity is increased when institutional actors and ecosystems also cut across scales of

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[73] For example, an objective for the criteria target stock (with the indicators a measure of biomass relative to unfished levels) may be: ‘maintain target stock in a healthy state’. An objective for the culture criteria could be: ‘maintain fishing as a culturally significant activity’.
[74] For example with the objective as ‘maintain target stock in a healthy state’ and the indicator a measure of biomass relative to unfished levels, the reference point could be: restore target stock biomass to 20% of unfished levels.

activity. As a result, indicator selection must clearly identify the scale of operation and sphere of influence while maintaining links to influences at higher and lower scales.

Some indicators lend themselves to interpretation across scales and can be easily aggregated and desegregated at the desired level. An example would be a fishery ecosystem indicator that measures habitat disturbance, e.g. the area trawled in km^2. This indicator could be used across a variety of scales. However an indicator that does not lend itself to generic application is the common biodiversity measure of threatened and endangered species. This measure may have significant varying interpretations at different scales. A species threatened at a local level may be common at the national scale. Therefore, caution must be exercised when identifying indicators for a particular scale. To be effective and reliable, the indicator must be tailored to particular uses and contexts in scale and content (Dahl 2000). It is important to specify in the description of the measure what geographical scale it is intended for and how the indicator should be interpreted. The higher the scale of the indicator, the lesser the resolution and specificity of the information.

2.6.3 Data availability

The availability and cost of obtaining data for new and existing indicators is a challenge to their effectiveness (Dhakal & Hidefumi 2003). New data requirements, especially in the ecological and social dimensions, must be underpinned by monitoring systems that feed into indicator systems (Dahl 2000). This will require efforts to produce, synthesise and monitor new data sets. For many indicators, the data is available, but needs to be harmonised with the indicator requirements and/or obtained from external databases or institutions. Monitoring is essential to maintain accurate measurements and adapt indicators to new data. When direct information for an indicator needs to be collected, proxies can be used until suitable information is available.

Indicators present an increasing burden for developing countries in terms of establishing multiple information and reporting systems. Ultimately indicator systems improve and facilitate efficient reporting practices, but initially will require substantial investment and resources (Dahl 2000; Bell & Morse 2001). Financial and technical support for nations developing indicator systems is essential if support is to be maintained for the process and progress is to be made towards globally representative initiatives.

2.6.4 Aggregation and Visualisation

The communication of indicator results is a critical phase often neglected in many initiatives (Bossel 1999; Jessinghaus 1999). To facilitate their use within broader decision-making regimes, and to make the results accessible to stakeholders, a strategy of aggregation and/or visualisation is critical (Bell & Morse 2001). While aggregation refers to mathematically based methods that condense many scores into a few compact indices, visualisation refers to the means of getting the indicator message across to the relevant stakeholders.

Aggregation is a major challenge for indicators and has been discussed in the literature (Bossel 1999). Achieving a few highly policy relevant indicators may be a desirable option for public consumption, the media and political purposes (Dahl 2000; Bell & Morse 2001). The use of GDP is an example of a highly aggregated index that has enormous weight in policymaking, but is extremely limited in terms of informing our progress towards sustainability. A key challenge is the development of an index that integrates the different dimensions of sustainable development and informs society (Jessinghaus 1999). The use of large lists of indicators, while desirable for expert-based decision-making, has received little support from political decision-makers (Dahl 2000). The momentum for aggregated indicators is expected to grow as their usefulness in decision-making is recognised (Bell & Morse 2001).[75]

(Dahl 2000) notes that from the start of the indicator process there has been a tension between politicians and experts in terms of aggregation. This issue revolves around the level of aggregation required based on political pragmatism traded against the accuracy of measurement of the system under study. This is shown in Figure 11 where an increased level of aggregation results in a smaller list of indicators and a loss of clarity (and vice versa). High aggregation / low clarity is preferred by political and media authorities while high clarity and low aggregation is generally preferred by the expert and management authorities. A balance between the two is an optimal approach - aggregated systems can reveal general trajectories to policy makers, but the system should allow for any problem to be traced back through the aggregation to specific measurements.

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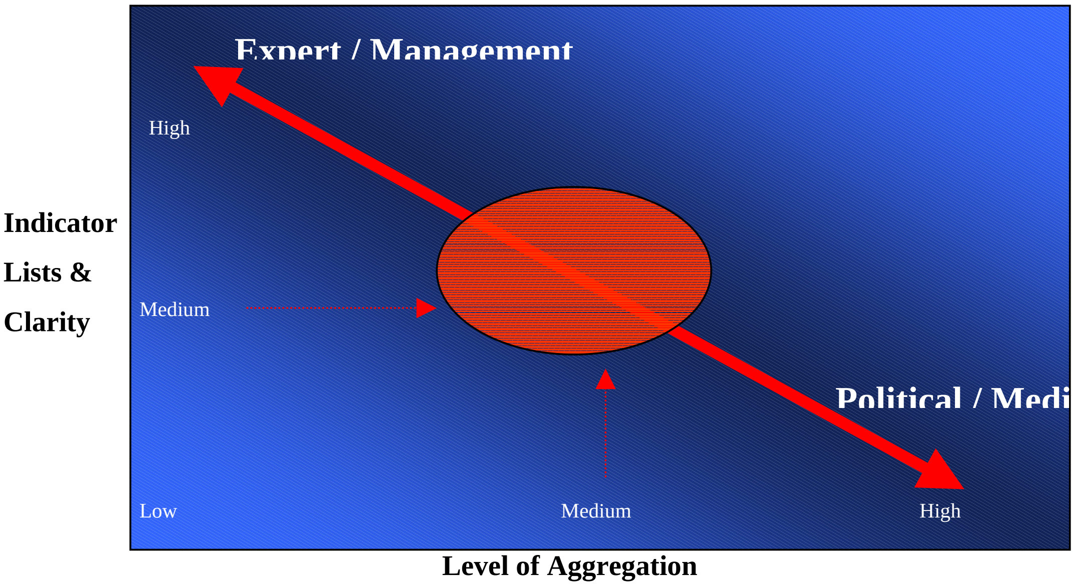
[75] Bell and Morse (2001) notes that while the 'usefulness' of sustainability indicators is widely recognised, the operationalisation of indicators to influence or change policy is still in its infancy. Empirical evidence in this thesis suggests that many initiatives are maturing and evolving towards decision techniques.

Weighting of indicators to reflect their relative importance is a critical issue in aggregation. At the present time there is no consensus or agreed methodology for weighting. Possible approaches include using expert opinion or analytical polling, but the majority of schemes apply equal weights to all indicator fields.

Figure 11. Trade offs between clarity and aggregation



2.7 Conclusion

Sustainability indicator systems have taken ‘a great leap forward’ since the declaration of the need for improved information for decision making in Chapter 40 of Agenda 21 (Bell & Morse 2001; Dhakal & Hidefumi 2003). The focus of the research has been on the development of methodologies and frameworks to order and present indicators, and the development of indicators for particular sectors (Bell & Morse 2001; Dhakal & Hidefumi 2003). Their specific application to fisheries systems, as a means to incorporate ecosystem-based and precautionary approaches, can be considered to be in an infant stage, but is progressing rapidly as the concepts and practice expand (Garcia 2000).

Indicators should not be taken out of context; they are a means to an end, and not the end itself (Meadows 1998). Whether an indicator system can deliver a definitive assessment that says ‘this is a sustainable fishery’ is yet to be seen in this evolving field. Chasing the ‘magic number’ may be a misplaced idea when examining the effectiveness of indicator systems. As suggested in the discussion above, the real effectiveness of the systems comes into play when they drive management changes, raise perceptions and identify gaps in current knowledge. This is difficult to evaluate, but the changes and influences driven by using indicator systems are subtle. Any evaluation of effectiveness must take this into account.

Developing an indicator system is an ongoing process, a means of expanding the traditional notion of management, and of communicating this information to decision-makers and a wide variety of stakeholders. Numerous challenges remain for implementation, including expanding the traditional biological target species focus, identification of objectives and performance measures, reconciling scales, data, aggregation and visualisation methods (Bell & Morse 2001; Dhakal & Hidefumi 2003). There is an urgent need for success stories and dissemination of case studies of documented indicator initiatives. This will provide a reference framework for further implementation, awareness of the benefits and pitfalls and eventually, a move towards a best practice standard for implementation and practice.

Chapter 3: Framework of Analysis

3.1 Developing a framework of analysis: the underlying foundations

3.1.1 Policy Analysis

What is the meaning of policy? Academics have debated this issue for several decades and like sustainability, a single definition does not exist. The *Oxford English Dictionary* describes the following as the chief living sense of the word ‘policy’: A course of action adopted and pursued by a government, party, ruler, statesman; any course of action adopted as advantageous or expedient’ (Hill 1997). Another definition by Friend states that ‘policy is essentially a *stance* which, once articulated, contributes to the context within which a succession of future decisions will be made’ (Hill 1997). Parsons (1995) concedes that the practice of policy can be more than an intended course of action, it can be something that is not intended, but is nonetheless carried out in the practice of implementation. The literature is replete with definitions of policy, but it can be seen from the above that policy is much about *process* and a means of ‘doing things’. Policy continually evolves and changes, it articulates the positions of institutions and encompasses the decision-making regime.

(Hogwood and Gunn 1984) note that policy analysis is about determining the characteristics, organisational and political setting of an issue, with the mechanics of the methods a secondary concern. Policy analysis therefore can be seen as an *applied* approach (Hogwood and Gunn 1984). Parsons (1995) describes how policy analysis has a number of common concerns:

- Concern with problems;
- Concern with the content of policy;
- Concern with the activity of policy makers and the inputs and process of a policy area;
- Concern with the consequences of a policy in terms of outcomes and outputs.

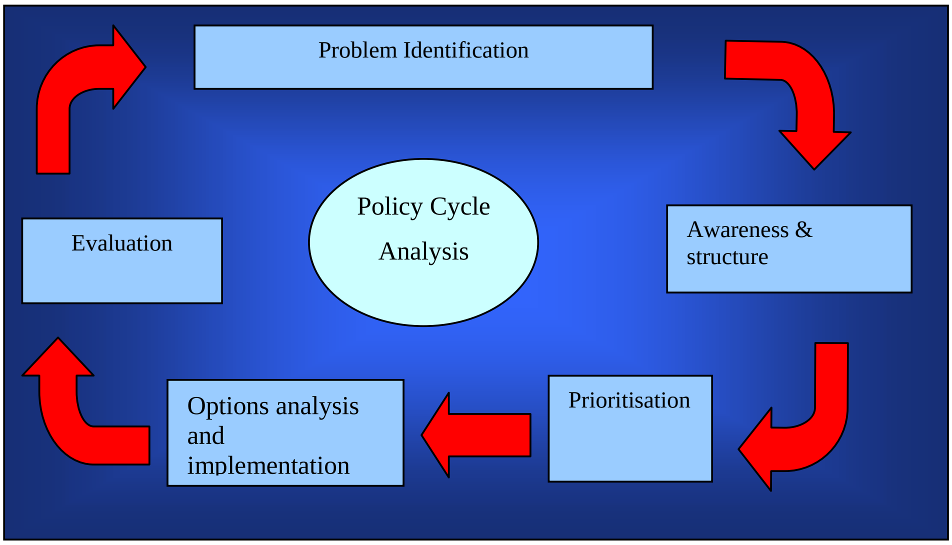
Issue orientated analysis has two simultaneous streams of concern that investigate an issue within the context of its political setting and examine its specific internal dynamics. With systems theory, the notion that a sub system affects broader related systems, and vice versa, is an important consideration in selecting the method of analysis (Bossel 1999). Understanding the broader setting of an issue is essential for placing the results of the subsystem into context.

Issue-based policy research is essentially directed towards solving problems that affect society, are problem orientated, and use descriptive and/or prescriptive techniques (Hogwood and Gunn 1984; Parsons 1995). The analysis is not a quick fix, but a means to highlight the crucial relationships and components of an issue that further informs choices in strategic decision-making (Hogwood and Gunn 1984).

Other forms of policy research include studies of the policy process, policy outputs, evaluation studies, information for policymaking and policy advocacy (Hill 1997). Generally the methods fall into two camps, analysis *of policy* and analysis *for policy*. However this distinction is arbitrary, and policy research mixes the different forms of analysis according to each particular case (Pal 1992).

When undertaking analysis there are several important stages. These stages are aligned to the management decision-making cycle, shown in Figure 12. While each stage is designed to facilitate a process for analysis, an overtly rationalist and scientific approach will not be suitable for complex socio-political problems (Pal 1992; Hogwood 1984). These stages while not obvious 'on the ground' do represent a structured approach to researching policy issues[76] and are useful for developing a methodological approach.

Figure 12. Stages in policy analysis.



[76] This process is also important for the development of indictors of sustainability, where indicators can be used at every step of the decision cycle. This is detailed in chapter 3, where the theory of indicators is expanded.

Problem identification is often cited as the central element in policy analysis (Hill 1997; Moldan 1997). Problem identification may lead to deeper underlying issues and complex problems, starting with the issue at hand and expanding to the broader system of concern. To understand an issue it may be necessary to observe the chain of events, the actors and pressures that result in the construction of each issue. It is important to consider the influence of values in the process as often the definition of a problem will be due to a particular value set that is held by the stakeholders (Dovers 2001). Once the scope of the issue is identified, it must be structured for analysis and prioritised for action. Descriptive or prescriptive policy analysis (analysis of policy and for policy[77]) needs to structure and prioritise for effective research solutions. Risk analysis can also be useful in identifying the components of an issue that require action[78]. Factors such as political, administrative, economic, and technical considerations may influence the prioritisation of strategies. Once the problem is identified a set of options for research can be presented.

Evaluation is a central component of an adaptable and flexible process. It is central to determining effectiveness in policy making (Moldan 1997).Evaluation can include real time analysis of a particular policy as it is being put into practice on an issue, or it can be retrospective, looking the past use of a policy. Evaluation is a link leading to the identification of new issues and moving the through the analysis cycle.

An important consideration in policy analysis is the use of qualitative and quantitative approaches. (Pal 1992; 66) states: *"We know that good analysis is not mathematics, there are no unique solutions or purely technical answers."*

Pal is at least partially correct. There are many approaches that use quantitative information in policy analysis, and useful models do exist to reach policy solutions. However policy research is multi-dimensional addressing issues that contain many components, many of which cannot be subjected to technical and 'rational' scientific analytical approaches. A method that combines forces - data from well designed scientific sampling programs, and an adaptable, flexible but structured process to use the information in a socio-political context, is required. The 'gap' between science and policy can be narrowed by the use of increasingly integrative approaches.

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[77] Refer to Hogwood & Gunn 1984; Hill 1997; and Parsons 1995.
[78] The NESDRF (Case 3) uses a form of risk analysis to identify the most important sustainability criteria for which objectives, indicators and reference points are developed. This leads to a cost effective and efficient process where effort towards non-essential criteria is avoided.

When dealing with multi-disciplinary issues, a mix of qualitative and quantitative methods is important. Investigating from one disciplinary angle may reveal interesting trends but will miss the complete picture. An example is the role of rational objective science and political decision-making. The role of science is to devise causal explanations about the world, which involves describing both the observable and unobservable processes that link phenomenon (Devine 1995). Scientific information provides a wealth of information that underpins effective decisions on natural resource management policy. Not all decisions in the policy arena, are however, made on the basis of rational and objective information (Dovers 2001). Political motivations are an important part of the decision-making 'mosaic' and often affect the outcomes of an issue. These motivations are real and influential. Decisions are made in a political context, with policy research contributing to the understanding of people as conscious and social human beings, with their motives, experiences and positions an important part of the causal process (Devine 1995).

While it is accepted that qualitative and quantitative methods are separate schools of thought, the distinction between the two should not be seen as mutually exclusive. Quantitative and qualitative methods collect and analyse data in different ways, and each approach should be assessed in terms of its suitability for answering theoretical and empirical questions (Devine 1995). All research methods have certain advantages and disadvantages that should be factored into the methodological requirements for the particular study. [79]

3.1.2 Models in Policy Analysis

To facilitate the analysis of policy and construct assessment frameworks, organise ideas, and generate concepts, the practitioner needs to reduce complexity to a level where analytical methods can be applied. (Parsons 1995) identifies the use of frameworks and models through which complex political processes can be explained. In using a model or framework, caution must be applied in the interpretation of the results. The use of a framework is a subjective view of the workings of a complex socio-political process. The analyst is creating order out of what does not have an objective order in itself (Parsons 1995). A model is a representation of reality and not reality itself. The models used in policy analysis are not testable in the scientific sense, but contribute to the understanding of an issue, how the issue developed, and what the consequences were. The use of models is an objective way of highlighting the values, assumptions and processes that influence policy, and subject them to critical analysis. They

[79] Devine 1995 & Miller 1995 provide a detailed account of quantitative and qualitative methods in policy research. In depth discussion on the methods used in policy can be found in this reference.

contribute to an increased understanding of policy issues and can be directly used in improving the process. (Parsons 1995) identified four general models that while separate in theory, are often mixed together in practice. They include:

- Explanatory frameworks describe the ‘way things work’. They can be heuristic, and provide a means by which complex problems can be investigated, or they can be causal and predict what will happen in a system based on empirical evidence.
- Ideal frameworks define the characteristics of an issue or process for the purpose of further comparison. Identification of these characteristics, and phenomena that drive them, can aid in explanation and analysis of particular policy issues.
- Normative frameworks are concerned with setting standards or desired states if the given goals for a particular issue are obtained. They can be a ‘road map’ for achieving or assessing progress towards a particular goal.

3.1.3 Comparative Research and Case Studies

(Rose 1991) states that the ‘comparative method involves the presentation of empirical evidence of some kind in an attempt to compare systematically and explicitly political phenomena.’ This definition is a useful starting point for outlining the methods of comparative research. Rose explicitly states that the comparative method is primarily between countries, and while this is certainly the case in many analyses, it is not the only cause for comparison. Comparison can essentially be between any units of scale or time, as long as the units of comparison are related. Comparisons are not restricted solely to spatial units, for example institutions may be the desired unit for comparison (a variety of natural resource management institutions within a region) or time may be the chosen variable (comparing a situation over a number of years). What remains important is that the units of comparison are justified in the study according to its goals and the comparison results in meaningful information about the system under consideration – not a haphazard collection of meaningless cases. Comparative methods are useful in policy research given the virtual impossibility of using a rigid experimental design, they allow for the investigation of a variety of issues at appropriate scales from which theories can be tested and insights can be gained. Therefore, the comparative method is an appropriate approach for testing the research questions in this thesis.

Case studies are an essential tool for investigating policy issues and are a common approach in comparative studies (Peachment 1993; Mackie 1995). Rigorous academic debate has occurred over what comprises a case study. A variety of views have been expressed ranging from purely scientific based observations in natural, management and political science to the broad value systems of bureaucrats, institutions and custom in the policy process (Peachment 1993). The truth is that there are many types of case study with spatial, temporal and institutional considerations. Each case study approach has its own merits and demerits but each tries to address a specific question. The key point is that the case study is designed for the policy problem and exists within a coherent analytical framework with the shortcomings of the methodological approach factored into the analysis.

Comparative case studies can provide useful insights into policy related research. This includes:

- The acquisition of factual knowledge about government process across jurisdictions;
- Providing valuable descriptions of the actions of actors in the policy process and the role of institutions and custom;
- Bringing together quantitative and qualitative information on particular issues or problems, that leads to informed decision making;
- Providing opportunity to test and generate theories and hypotheses on policy; and
- Contributing to the broader understanding of issues that cross jurisdictions, countries, and cultures.

Several important considerations underpin the use of comparative case studies. These considerations include:

- Taking into account how many cases are examined, trading detail against generalisation (Mackie 1995). More cases will have less detail but provide broad conclusion;
- The choice of case studies must be justified. This gives analytical and decision power to the results;
- The structure of each case study must be defined and justified;
- An explicit ‘terms of reference’ or analytical framework must be detailed for the case study research. This places the particular selections and the comparative approach within the context of the research aims.

(Peachment 1993) notes that one of the major limitations of using the case study approach is the issue of making generalisations about complex policy issues from relatively simplified case study approaches - the ‘dip stick’ problem. This is an issue that must be considered when interpreting the results of case studies, but one that can be minimised through careful selection of studies and a rigorous analytical structure. The case study process essentially aims to describe and analyse the complex processes that underlie policy issues within a framework of *reality*, not to disregard them. It applies the policy process and associated hypothesis to cases of genuine concern that are essentially resistant to rational scientific experimental methods. The rationale for case studies is highlighted by (Weller 1980; 500) who states that the study of public policy must show:

> *Concern with political activity, with the development and content of policies, with the processes which shape them, and the institutions which mould them. These factors simply cannot be readily separated. Whether individual studies concentrate on policy or process or institutions; the drawing together of those threads is at the centre of our concern.*

It is the ‘drawing together of those threads’ that is the design feature of the case study method. Case studies, as a part of comparative policy analysis, are a suitable vehicle for examining the application of sustainability indicator systems in fisheries management.

3.2 Research on sustainability indicators.

3.2.1 Policy research for sustainability: underlying issues.

Researching sustainability issues requires a different approach from the traditional science and policy perspective as issues are integrated and contain environmental, social, economic, technological and institutional components. The research is multi-disciplinary and is primarily concerned with *linkages.* Sustainability information aims to use scientific information with policy instruments to provide integrated decision-making for recognised problems. Without good scientific information and a coherent policy structure, sustainability decision-making will be severely impaired. Institutions are investigating and applying a variety of policy tools and management approaches to address sustainability questions (Dovers 2000).

There are several crossing-cutting issues within sustainability that must be accounted for when pursuing research (Dovers 2000). These attributes spread across the entire sustainability field, from indicator initiatives to other processes such as integrated management. For effective policy research into sustainability issues the following cross-cutting themes must be considered:

- **New forms of data and information**. Sustainability issues are multi-disciplinary, integrated and require innovative sources of information (Dahl 2000; Venning 2001). This requires new monitoring and measurement techniques that can be synthesised with traditional techniques (Meadows 1998). An important consideration is the flows of information to users and decision-makers and feedback mechanisms. The generation of information is an important consideration, but equally important is how that information is transferred and used in a management context (Bell & Morse 1999). The visualisation and communication of sustainability information is an emerging field within the discipline and underpins the success of many initiatives (Garcia 2000).

- **Spatial scales** are critical when researching sustainability issues and are particularly acute in developing indicator systems. Scale is important for defining the specific issue, the approach to measurement and the outcomes in decision-making. Most environmental and economic issues cut across several scales [80](Dovers 2000). Scale issues can be identified at the vertical (local, national, regional, international) and horizontal levels (across sectors, government departments and institutions) (Moldan 1997). This requires an integrated approach to data gathering, analysis, and decision-making. Despite being at an embryonic stage (Berkes et al 2001; Venning 2001) the notion of integrated management is increasingly being recognised as a leading tool and is developed with indicators to address spatial issues.

- **Temporal scales**. Sustainable development by its very nature is a temporal process as it involves ongoing adaptable change and improvement over time (Moldan 1997). Temporal considerations feature prominently in many indicator systems, as an assessment over time will be a significant output.[81] However all indicators are not solely focused on temporal measurements.[82] The temporal scales of sustainability issues can vary, but are generally longer than short-term political and socio-economic scales of activity. Environmental issues and natural processes can vary between decades to hundreds of years (Dovers 2000). The reconciliation between short and long time frames is an important point in sustainability research.

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[80] For example the issue of biodiversity crosses several governmental jurisdictions with different responsibilities and commitments within each jurisdiction to address the problem.
[81] Most indicators are measured in a temporal context (e.g. employment, income, biomass) to assess the trend over time and give a reasonable observation of the performance of the indicator.
[82] Moldan (1997) notes that several indicators that are used for cross sectional studies have space (landscape) and population indicators as the main focus of the system.

- **Transparency and involvement**. Managing sustainability involves incorporating the needs of users of the information; it requires participation, community involvement, transparency of decisions, and consideration of all affected stakeholders (Meadows 1998; Rhydin 1999; Clarke 2002). Such decisions will be more effective due to the broad ownership of affected stakeholders (Rhydin 1999). Obtaining consensus at different stages of the process is a challenging; in fact it is still relatively unknown at what stage the broader stakeholders should be engaged in decision-making and how they should be engaged (Dovers 2000). However, the fact remains that building support for an initiative is critical if it is to succeed in changing attitudes toward sustainability and will likely avoid expensive litigation.

- **Uncertainty.** Uncertainty pervades all aspects of sustainability decision-making. There is uncertainty in decision processes, in the state of natural systems and the impact of human activities upon natural systems. Decisions will always involve a certain amount of risk and uncertainty (Dovers 1995). Directly addressing the causes of such uncertainty through a variety of tools and precautionary measures such as indicators and risk assessment will reduce the level of uncertainty over time.

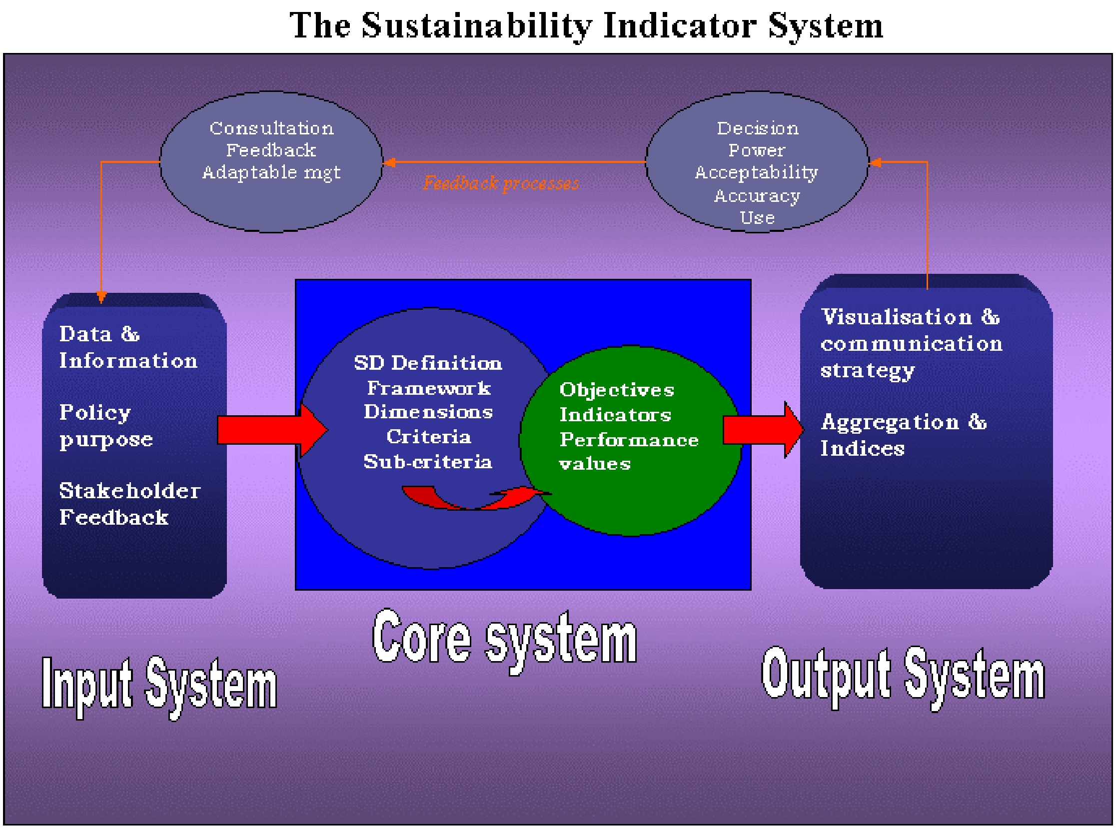
3.2.2 Defining the Sustainability Indicator System.

Parsons (1995) highlighted the usefulness of conceptual models that can explain complex political processes and issues. Sustainability indicator systems encompass a variety of frameworks, dimensions, criteria, indicators, targets and visualisation strategies. The variety of processes and measurements can be analysed from a systems approach and classified by policy purpose and scale. A key component of the system is the interpretation of the term sustainability and how the concept is applied to the particular issue.

Sustainability indicator systems (SIS) can take many forms and purposes. The variety of systems in use in fisheries management has grown in the last five years, with many SIS in early stages of development. Several use a common base framework (such as the Pressure-State-Response model) and SIS within a sector tend to use similar indicators (for example forestry or fisheries systems). It is unproductive and absurd to prescribe a fixed and rigid ‘model’ of an indicator system that will apply to all SIS in all aspects of the sustainability policy process. There is no absolute answer - rather different approaches to interpreting sustainability are based on differing policy needs and structures. However, a conceptual model can be identified that highlights the core processes that underlie and influence sustainability indicator systems. This model is based on the peer-reviewed literature and empirical evidence from indicator practice (subscribing to a positivist approach). The model focuses on the core indicator system as dependent upon a series of inputs and outputs to operate effectively (Figure 13). Inputs involve information to construct the indicators and develop an appropriate structure for the policy need while outputs involve the use of the indicator results in a fashion that results in informed and improved decision making.

In this thesis, the first step is to define an indicator system model that will form the basis of the comparative investigation. The model is used to simplify the diverse elements of indicator systems, subject them to case study analysis, develop an explanatory approach, identify common structures and processes, and explore the basis of an indicator system standard. The model forms the basis of the analysis and links to an assessment framework (see below). The SIS model below contains elements of explanatory, ideal-type, and normative frameworks as described above by Parsons (1995). The conceptual systems model is shown below in Figure 13.

Figure 13 The Sustainability Indicator System Model.



On the basis of the model, a Sustainability Indicator System can be defined as:

> *A structured system that is used to define, measure and implement information that directly relates to effective decision-making regarding sustainability or its primary dimensions.*

This definition is useful for a broad classification of indicator systems. To identify case studies a increasingly refined description is needed. Using Figure 13 as a guide, the indicator system is broken into interrelated components. These consist of the core system and its inputs and outputs. The performance of the core system is directly influenced by the inputs and outputs with the effectiveness of the whole system a function of the effectiveness of each of its components. The operation of the core system is of a primary concern: its failure could effectively render the system inactive. Using an ecological analogy, the core system is a *keystone species.* The failure of the inputs and outputs will not directly lead to a system 'collapse' but remain highly influential on the operation and influence of the overall SIS. The components of the SIS can be defined as follows.

The core system:

> *The* ***core system*** *is made up of the sustainability definition, the framework for the information structure, its dimensions and criteria and its associated subsystem of objectives, indicators and performance measures. The subsystem structures data and information that assesses the higher level and complex environmental, economic, and social dimensions of sustainable development.*

The input and output systems:

> *The core system exists within a broader network that is involved in policy and management decision-making, feedback, and analysis. The inputs and outputs directly relate to the effectiveness of the core system through setting the policy agenda, presenting the results to the relevant decision makers, and integrating with other reporting systems.*
>
> ***Inputs*** *comprise what is coming into the system. This includes forces that influence the design and purpose of the core system, including the results of monitoring and feedback. The use and users of the SIS is an important consideration, as is the broad policy setting*

of the relevant issue. Feedback from previous SIS is essential to improve the quality of information and process.

Outputs *represent how the information from the SIS is used in decision-making. The information may have to be aggregated for different audiences. In addition, a visual design and communication strategy should be used to transmit information to stakeholders and decision makers. These outputs reflect the decision-making power, acceptability and accuracy of the SIS.*

Historical research on indicators has been descriptive in nature. This has been useful in the developmental phase of indicator application. Descriptive research has elaborated the frameworks, criteria and indicators used in several sectors (SCOPE 1995; Dahl 1995; Hardi et al 1997 ; Moldan 1997; Bell & Morse 1999; Bossel 1999; Dahl 2000). The descriptive research has contributed to large lists of indicators with little strategic evaluation of their repercussions within fisheries systems. Table 5 below summarises the research progress and anticipated direction with indicators.

As shown in Table 5 it can be observed that the research directions for indicators are shifting from descriptive to strategic approaches. There is an identified need to generate indicators and performance measures for non-traditional fields such as social aspects of sustainable development, and to tools presenting indicator information to decision makers and stakeholders using aggregated and dynamic formats.

Table 5. Current and future research directions of sustainability indicator systems

Current Research	Future Directions
Descriptive based: elaboration of frameworks, dimensions, indicators and criteria.	Strategically based: assessing SIS according to analytical criteria, best method for best issue. Setting objectives for indicators.
Sector and issue based.	Integrated, broader horizontal reporting across sectors.
Limited integration of vertical reporting.	Scale dependent indicator systems, move towards integrated vertical reporting.
Biological / economic indicator focus.	Ecosystem and social indicator developments.
Descriptive lists of indicators.	Aggregation and indices.
Generating results.	Communication of results.
Static indicator lists.	Dynamic frameworks that account for uncertainty, non-linearity and feedbacks.

3.3 The Assessment Framework

3.3.1 Overview and structure

The assessment framework developed in this thesis is the basis of a comparative policy study that examines the use of indicator systems in fisheries management. It is an evolution from previous descriptive research, with its basis in a systems perspective and meta-analysis across multiple jurisdictions. The assessment framework and its criteria were distilled from the SIS model in Figure 13. The model / assessment framework drew from the peer-reviewed literature in Chapter 2 and empirical evidence to produce the key criteria for an indicator system. In particular this thesis draws from sources such as Meadows (1998); Bell & Morse (1999), Bossel (1999) and Dovers (2001) who advocate a systems approach to the development and analysis of indicators and the development of criteria for systems assessments.

Any fishery is a complex system with ecological, social and economic components. A system can include multiple species, habitats, stakeholders and regulatory frameworks (Lane 1996). Any analysis calls for a multidisciplinary approach that acknowledges the links between ecosystem dynamics, fisheries management, and human behaviour (Bowen 1996; Charles 1997). All 'dimensions' affect the sustainability of the fishery. There are a variety of approaches that report on the sustainability of fishery systems and take into account different dimensions. Majority of systems have focused on the ecological dimension but recent initiatives are pushing towards the development of socio-economic indicators. Approaches range from broad status report 'snapshot' approaches [83] to strategic fishery assessments.[84] The assessment framework provides a means of comparison between SIS and presents an analysis of reporting approaches across several jurisdictions. The aim of the assessment framework is to examine the underlying processes that make sustainability indicator systems effective. This includes the technical aspects of sustainability assessment, but also the identified aims of indicator systems to improve policy dialogue, communicate findings and orientate management towards sustainability outcomes. The systems approach taken by the assessment framework covers all the components of an effective indicator system as applied to fisheries management.

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[83] For example, the State of the Environment report would be a snapshot approach.
[84] For example, policy based assessments and certification initiatives would relate to strategic assessments.

The framework is composed of 4 strategic criteria, 17 sub criteria and 31 operational criteria designed to evaluate the case studies on sustainability reporting (Table 6 below). Three of the four strategic criteria have been drawn from the SIS model and include Strategic Outcomes, Systems Process, and System Features. The fourth strategic criteria is drawn from the literature dedicated to fisheries management and is termed Fisheries Issues. Each strategic criteria is described in section 3.3.3 below. Each criterion has been developed in relation to the literature on sustainability indicators and aims to capture the critical focus points of an indicator system.[85] The criteria cover many issues including how the system views sustainability, essential processes and structures within the system, 'best practice' concepts and issues that are specific to sustainable fisheries management.

The assessment framework uses a process of hierarchical sub division to break down the broad criteria into specific, operational criteria.[86] This way, the assessment framework aims to provide a link from the strategic through to the operational. The performance of the strategic level component can be described by the aggregated performance of the lower level sub components. For each of the lowest level criteria a simple scoring method has been designed to measure the performance of each case. Each score is then aggregated and averaged for the operational criteria and plotted on the orientation graphs as the basis of discussion. For each case study scoring will identify and assess the SIS performance against the framework and highlight the strong and weak points. A detailed description of each strategic, operational and sub-criteria, and the process used to score them is given in 3.3.3 below. The assessment framework is shown below in Table 6.

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[85] Each criteria is matched with a particular reference.

[86] This hierarchical process of subdivision and categorisation has been used in other fields of related sustainability research. For example, Hyatt (1999) recommends this process for examining the role of sustainability indices, Charles (1997) examines the policy direction of sustainable fisheries using a categorised framework, Chesson (1998) uses a process of subdivision to implement sustainability in fisheries, and Garcia (2000) and Garcia *et al (*2000) subdivided and categorised the FAO Code of Conduct into criteria for indicators.

Table 6. The Assessment Framework for Sustainability Indicator Systems.

Strategic Criteria	Operational Criteria	Sub-criteria
1. Strategic Outcomes	1a. Understanding the focus system	*System state and viability*
	1b. Contribution towards other dependent systems	*System contribution to broader societal sustainability.*
2. System Processes	2a. Core Structure	*Interpretation and definition of sustainability.* *Framework classification.* *Dimensions of sustainability.* *Criteria and sub-criteria.*
	2b. Core Sub-structure	*Objectives* *Indicators* *Performance values*
	2c. Input processes	*Policy context* *Indicator feedback* *Stakeholder / user feedback*
	2d. Output Processes	*Visualisation & presentation.* *Communication & reporting* *Aggregation & scorecards* *Decision making influence*
3. System features.	3a. Integrative capacity.	*Interaction of sustainability dimensions.* *Integration with other reporting systems ad sectors.*
	3b. Adaptive Management	*Social and institutional indicator development.* *System monitoring and feedback.*
	3c. Participation	*Participation of stakeholders* *Participation of decision makers and relevant institutions.*
	3d. Project Management	*Institutional Capacity* *Marketing and R&D*
4. Fisheries specific issues	4a. Incorporates Ecosystem Management Principles.	*SIS reflects broader ecosystem based management principles*
	4b. Target Species info	*Indicators assess state of the target stock, used in management plans.*
	4c. Recognises uncertainty.	*Assessments quantify and explicitly recognise all forms of uncertainty in fisheries.*
	4d. Identified relationship to fisheries management.	*Indicators feedback to management.*
	4e. Static vs. dynamic.	*Static and dynamic reporting within SIS.*
	4f. Context sensitive.	*Does the SIS take specific fishery context issues into account?*
	4g. Fisheries specific info	*Information on overcapacity, subsidies, trade, fleet structure, IUU fishing and external influences.*

3.3.2 Relationship between Policy Literature and the Assessment Framework

The discussion on policy highlighted that decisions are not always made on a rational, information-centric basis. Dovers (2001) highlights that decisions are not always made in a 'rational' manner based on 'objective' information an can be influenced by political forces. This issue is compounded in sustainability decision making, where environmental, social and economic issues interact across scales, times and jurisdictions. Political values are inherent in sustainability decision making – it is naive to expect that decisions will be made on the basis of good information alone. Nevertheless 'good' and 'scientific' information is critical for policy analysis. The emphasis should be placed on how this information is utilised within the broader policy process.

This observation underlies the development of the SIS model and the selection of the assessment criteria. It is also an influence in the selection of a diverse set of case studies. Indicator systems lie at the nexus of the science and policy disciplines – they take from and give to both (see Chapter 2). The SIS model and the resulting assessment framework account for these considerations. Strategic Outcomes (see Table 6 above) refers to the broad scope of indicator systems in terms of how they approach sustainability in an internal and/or external policy context. System Processes investigate the mechanics of indicator systems across a range of influences. For example, there are references to data and information processes, policy relevance, communication, reporting and influence. System Features examines important aspects of sustainability decision making while Fisheries Issues explores fisheries management outcomes. Therefore, the assessment framework explicitly accounts for the role of information and complimentary / competing policy influences within the overall indicator system.

As noted by Hogwood and Gunn (1984), policy analysis is about determining the critical characteristics of the issue. The analytical method was designed to 'deconstruct' the process of using indicators in policy and subject it to analysis. The proposed assessment framework achieves this goal by breaking down the artificial idea of the SIS into four key criteria, based on the reviewed literature and empirical indicator practice (see Table 6). The criteria are applied to several fisheries case studies. The assessment framework allows for a detailed examination of the content, mechanics, implementation, and the consequences of attempting to assess and implement indicator-based management in fisheries. The critical characteristics of the issue have therefore been identified.

The methods fit Parsons 'issue-orientated policy analysis' (Parsons 1995) directed at examining key policy issues. The assessment framework– by identifying the key characteristics of the issue – allows for a strategic analysis of timely, current, and real life policy issues within the fisheries sector and informs further development. The method embraces a descriptive (looking at how SIS function) and prescriptive (improving the strategic use of SIS) approach. The use of conceptual models to examine policy issues is examined by Hogwood and Gunn (1984), Pal (1992), and Parsons (1995). The SIS model that underpins the methodology is an analytical lens that can be used as a tool to examine live policy issues. The advantages to this approach lie in being at the policy 'coal-face' and influencing the development of new systems. The disadvantages stem from examining live issues that can change rapidly and are subject to political influences.
The model has been constructed with elements of explanatory, ideal and normative approaches as described in section 3.1.2 above.

3.3.3 Criteria and Scoring

The framework sets out 4 strategic criteria, 17 sub criteria and 31 operational criteria to assess the performance of the sustainability indicator systems. At the top of the hierarchy Strategic Outcomes, System Processes, System Features and Fisheries Issues make up the four key components of an SIS. These criteria represent the SIS outcomes - comprehensive and strategic sustainability assessments, a functional and pragmatic structure and process, adequate representation of policy issues, and relevant to fisheries management outcomes. Each of the strategic criteria is divided into operational and sub-criteria that focus on specific elements of the system. A description of each criteria, operational criteria and sub-criteria is provided, with supporting references.

To assess the performance of each sub-criteria a scoring system has been devised. The four step scoring system is based on a 'key' – the performance of each case is can be scored against this key. This approach is based on an adaptation of the systems detailed in Moldan (1997), Fisheries Centre (1998), FAO (1999c), Adler et al (2001), Dovers (2001) and Kurtz et al (2001) who establish criteria based keys to assess the performance of fisheries, institutions, and policies. For each criteria a score from 0-3 score is allocated, based on its performance from poor (0) to advanced (3). Each 'step' in the key represents a progression from a poor to an advanced stage for that criteria with each step described in detail. For each of the 31 sub-criteria, the steps between each scoring post are relatively the same (ie. Going from a 0 to 1 or going from a 2 to 3 is similar across all criteria). A generic key for the scoring process has been developed and is displayed below.

Assessment Criteria

0 - The lowest level of performance for the SIS in relation to the criteria. For this score, the SIS has failed to achieve or address the listed assessment criteria.
1 - The SIS has achieved a minimal or basic level of performance. This score relates to an ad hoc, narrow or undeveloped approach against the criteria. It can also refer to a formative, 'on paper' commitment that is yet to follow through into practice. Many limitations.
2 - The SIS has achieved a sufficient level of performance in relation to the criteria. The SIS has addressed the assessment criteria, but further development is required. There is an identified commitment to the criteria with ongoing implementation. Some limitations present.
3 – The SIS has achieved an advanced level of performance in relation to the criteria. The performance can be considered a best practice approach.

Once scores have been obtained for each sub-criteria they are aggregated to the operational criteria level by an averaging process. The mean of each operational criteria is plotted by the way of orientation graphs for each case study. These graphs are a useful means of identifying trends and performance within policy systems (Bossel 1999). Results are displayed for each case study under each assessment criteria, and a summary graph of the scores is presented. Therefore, for each case study, the performance or 'behaviour' of the indicator system can be observed. Using orientation graphs, specific areas of improvement or deficiency can be highlighted. These scores are aggregated and graphed at the strategic criteria level to determine the overall performance of the SIS.

It is important to note that the scoring procedure is a subjective process that is based on a review of the published literature, grey literature, legislation, industry perspective, consultation with practitioners and empirical practice. The justification for each score is transparent and clearly stated within each case study – and open for debate. The scoring process is not designed to provide a mathematically verifiable analysis. Rather, the approach seeks to compare and scrutinise a series of complex, live, highly integrated, and value based policy processes. The scoring method allows for a degree of flexibility in the investigation of these systems whilst providing the basis for a detailed and consistent comparative analysis. The outcomes from this scoring approach allow for analysis of the relative strengths and weaknesses of each reporting system and recommendations for the future development of each SIS. It allows for the development of a systems 'map' for each SIS, a display of the inter-related components and processes with each SIS, and analysis of the strong and weak points.

1. Strategic Outcomes

This criteria refers to the vision and objectives of the SIS and the way it approaches the assessment of sustainability. It refers to the strategic vision and scope of the SIS and the 'prime operational directive'. It sets the fishery based SIS within the wider context of policy development and decision making (often competitively). This criteria is important as it establishes the overall drive of the SIS in terms of understanding the fishery context and the broader policy context. As identified in Bossel (1999) indicator systems should provide vital information on the viability and state of the system under investigation and provide information about the systems contribution to the performance of other systems that depend on them. Strategic outcomes is split into two operational criteria: Understanding the focus system and Contribution towards other dependent systems.

1a. Understanding the focus system.

Does the SIS contribute to the understanding of the focus system (ie. A sustainable fishery). Does it simplify the core elements of a sustainable fishery system for decision makers, the public, or stakeholder discussion and analysis. The SIS should make the 'equation' of the fishery visible and influences explicit. This component is assessed by scoring the SIS contribution to understanding the fishery system state and viability (Bossel 1999) and its attempt to understand the fishery dynamics (Dahl 1995; Dahl 2000; Garcia 2000).

System State and Viability
0 – The SIS offers no information to assess state & viability of the fishery.
1 – Minimal understanding of relationships, influences & state of the fishery.
2 – Good understanding of relationships, influences & state of the fishery.
3 – System is well understood and documented. Highlights the processes / influences within the fishery.

1b. Contribution towards other dependent systems.

This component is difficult to assess - how the fishery system, through the SIS, contributes to a broader societal notion of sustainability. This implies a value-based judgment including the fact that despite the fishery system being sustainable on its own, it may lead *away* from societal goals (Chesson 1998; Chesson 1999). Does the SIS contribute to an understanding of the role of the fishery in a broader systems context (Bossel 1999)? Does the SIS integrate with broader policy approaches (For example, national strategies on sustainability, regional planning instruments, Oceans Policies etc.). This links with criteria 1a, and places the focus system in a broader strategic context.

SIS Contribution to broader societal sustainability

0 – No identified relationship to other dependent systems or broader policies.

1 –Single-issue focus with minor integration with broader policy.

2 – SIS encompasses a broader societal view of sustainability and is in initial stages of policy integration.

3 – SIS assesses the focus system in addition to clearly demonstrating a relationship to broad societal sustainability issues and broader policy.

2. System Processes

System Processes represent the operational machinery of the SIS – how the system works to assess, report and manage sustainability. This criteria is based on the conceptual SIS model that identifies the generic structures and processes. These processes are the essential 'nuts and bolts' of the system, as identified in the model. This is an important criteria for any indicator system in any sector. The literature and empirical evidence clearly states that indicators must be assembled within a defined process – ad hoc systems can lead to the wrong messages being interpreted (Meadows 1998). System Processes is divided into the *core structure, core sub-structure, input processes, output processes.*

2a Core Structure

This is the central component of the SIS. For measurement and assessment of sustainability to be effective the core structure needs effective and coherent components: an accepted definition; an appropriate organising framework, and identified dimensions that split to measurable criteria (SCOPE 1995; Meadows 1998; Bell & Morse 1999; Bossel 1999). This structure is not set in stone but ordering is necessary for clarity and a clear message.

Interpretation and definition

0 – No agreed definition on sustainability.

1 – Vague or narrow definition of sustainability.

2 – General definition exists but does not drive the framework.

3 – Explicit, agreed definition, focused, acts as vision.

Framework Classification

Does the SIS have an organisational framework for ordering the information on sustainability?

0 – No framework.

1 – Ad hoc framework that recognises some dimensions of sustainability, not based on identified policy needs.

2 – Framework that lists the dimensions. A justification exists for using the framework.

3 – Advanced framework that demonstrates relationships between dimensions and is based on the definition. Strong justification or scientific basis for framework and linked to policy outcomes.

Dimensions

Does the SIS focus on one dimension of sustainability eg. the economic or biological dimension, or is there an attempt to capture a holistic view of the marine system.

0 – Focus on one dimension. No acknowledgment of other related dimensions.

1 – Narrow focus but recognition of other dimensions to sustainability.

2 – Multiple dimensions are recognised but more information required. Formative stages.

3 – Broad focus and recognition of multiple dimensions developed throughout SIS. A comprehensive statement of sustainability.

Criteria and Sub-criteria

Dimensions are subdivided into meaningful scale relevant criteria – the criteria are operational aspects of sustainability for the fishery in relation to the dimension (eg. The criteria 'target species harvest' relates to the 'biological' dimension). Criteria may further divided to reach a practical level. Management can directly affect the criteria.

0 – Non-existent or vague criteria.

1 – Criteria exist but are ill defined and haphazard. Not linked to the dimensions or supported by indicators.

2 – Developed criteria based on the higher classifications and flow to indicators.

3 – Developed criteria, fishery relevant, documented and based on latest research. Clear link between definition, dimensions, criteria and flow on to indicators. The 'unpacking' process is justified.

2b Core Sub Structure

The substructure acts as a 'package' to describe and measure each identified criteria. The best practice literature states that for each criteria, an objective, indicator and performance measure should be established (Bell & Morse 1999; Fletcher et al 2002; Dhakal and Hidefumi 2003).

The varied approaches to assessing sustainability result in a variety of quantitative and qualitative methods. These approaches can be analysed using the SIS model. For coherent measures, the system should set realistic policy based objectives (Chesson 2000; Arbour 2001), accurate and useful indicators based on relevant information (Hardi et al 1997; Moldan 1997; and Dhakal and Hidefumi 2003) and performance measures that act as policy triggers (Bakkes et al 1994; Garcia 2000). The core sub structure is highly relevant for all SIS. Research and application to date has focused on the description and improvement of objectives, indicators and performance measures. Many systems have yet to develop a core sub structure across all identified dimensions and criteria. This is particularly the case with the socio-economic dimensions of sustainable fisheries.

Objectives

The objectives are simply what stakeholders want to achieve- what are the aims and are they present within the SIS. Do they set the direction for indicator measures? Are they based on policy outcomes / priorities?

0 - No objectives set in the SIS.

1 -Objectives exist but not linked to the SIS. Diffuse objectives. Vague.

2 - Objectives are included in the SIS. Not clearly linked to indicators - further work required.

3 - Clear objectives for each criteria, related to indicators, understood and accepted. Objectives are based on policy outcomes.

Indicators

Indicators are the unit of measurement that provides information about an aspect of sustainability (ie. the dimensions and criteria). Indicators can be quantitative or qualitative measures. Indicators should be scientifically feasible and policy relevant.

Scientific

0 – Vague, uncertain, no information. Lack of relevant measures.

1 – Developmental indicators. Data being collected. Uncertain but improving.

2 – Appropriate scientific basis, ongoing research. Use of proxies. Data collection occurring.

3 – Clear, robust, measurable, researched indicators. Time series.

Functional

0 – Irrelevant, highly technical, no agreement.

1 –Minimal links with policy, not enough information to facilitate decisions.

2 – Policy relevant but not a direct link. Improving trend or recognition of issue.

3 – Policy relevant, compelling, facilitate decisions. Balance between technical & relevance.

Performance Values

The performance value (and associated reference points) set a target or limit level on the indicator measurement to interpret and assess performance over time. Performance values make the indicator relevant and accountable.

0 – No performance measures.

1 – Performance measures set for some indicators – haphazard approach.

2 – Basic performance measures exist for majority of indicators. Not linked to actions.

3 – Clear, effective performance measures and reference points for each indicator. Actions specified.

2c Input Processes

Does the system take into account new information and input this into the SIS (For example, new research, community input or policy priorities). These variables drive the context setting and information content – what is coming into the system. Input processes are essential for setting the context, the policy relevance, using monitoring results and feedback, and the outputs of adaptive management (Hardi & Zdan 1997; FAO 1999a; Jesinghaus 1999). Input processes consist of *policy context, indicator feedback, and user feedback.* All SIS, regardless of sector, should aim to maximise input and feedback as a part of continual improvement (Dhakal and Hidefumi 2003). This criteria is difficult to score in relatively new cases that have not established feedback mechanisms.

Policy Context

The SIS fits into or links to a policy framework that defines its purpose and structure. This framework defines the scope and purpose of the SIS, with the SIS in turn influencing policy.

0 – No existing broader policy framework.

1 – Minimal policy direction is provided. SIS not linked to policy.

2 – Broad policy network exists, but SIS avoids integration.

3 – Specific defined policy framework defines and guides the SIS and uses its results.

Indicator Feedback

This asks whether the SIS reviews the performance of the actual indicators – do they reflect trends in the actual variable (criterion) of interest. Need to test validity and improve the use over time. Does the process for selecting initial indicators feedback into development of the SIS.

0 – No planned review or testing of indicators.

1 –An 'on paper' commitment exists. Minimal feedback process.

2 – A regular feedback system is included in the process. There is evidence of debate & feedback in indicator selection.

3 – Regular established feedback protocols, incorporation into system. New indicators subject to review and testing.

Stakeholder / user feedback

Is feedback from user groups incorporated into the SIS. Perceptions of the use of the system will influence its effectiveness and get 'buy in' from stakeholders.

0 – No user feedback.

1 – Irregular, minimal or singular feedback.

2 – Informal, not core part of the approach.

3 – SIS designed for regular feedback from users and published.

2d Output Processes

How the information is used from a SIS is vital to its success (Dhakal and Hidefumi 2003). An adequate form of reporting and communicating the outcomes is essential to signal progress towards (or away) from sustainability (Jesinghaus, 1999; Bell & Morse 2001). Reports should be well structured and clearly deliver the message for decision makers and the public (Garcia 2000; Potts 2001). Output processes is sub-divided into *visualisation and presentation*, *communication and reporting, aggregation & scorecards, and decision-making influence.* Output process have been generally under-developed in SIS – as a result of the research focus being on indicator development. This is a critical point, as it is the *transmission* of information that is a key aspect of decision making in a political context.

Visualisation and presentation

An effective visualisation strategy enables clear, rapid, assimilation of SIS information and promotes wide discussion and debate. Visualisation is important for summarising lengthy indicator reports. It also relates to how easy the document is to read.

0 – No visualisation strategy

1 – Minimal or poor use of visualisation techniques. Message is not clear.

2 – Visualisation strategy used but in developmental phase.

3 - Clear, effective, and innovative visualisation of indicators.

Reporting and Communication

Does the SIS produce a report that contains a description of the methods, results, interpretation and conclusions? Does the SIS have a sufficient reporting mechanism for describing the process used?

0 – No formal reporting system.

1 – Minimal reporting - poor presentation of information.

2 – Reporting of results and methods in an informal way. Difficult to link methods / indicators / & results to conclusions.

3 - Regular updated reports to users and stakeholders. Indicators and methods justified. Clear interpretation of indicator results.

Aggregation & Scorecards

One of the key challenge areas for indicators. Aggregation into indices or using summary scorecards is useful for presenting results to the public and decision makers but can result in a loss of analytical power. Does the SIS engage or discuss aggregation, or use a method for summation? Scorecards are a useful way of summarising information for decision makers – is this process used. This score relates to the simple but effective transmission of information to stakeholders.

0 – No methods for aggregation, scorecards not used.

1 – Aggregation and scorecards are intended but SIS is developing the means.

2 – SIS is testing of methods and approaches of aggregation or simplifying indicator information.

3 – Innovative aggregation methodology. Scorecards or equivalent are used to summarise and transmit indicator results.

Decision making influence

Does the SIS influence broader decision making for the fishery. Are the results linked to planning, licensing, or regulatory levers? Is there any perceived influence of the SIS on decision-making?

0 – No perceived influence in decision-making.

1 – The SIS has minimal, informal influence. Focus on reporting and education.

2 – The SIS is evolving increasing influence, an assessment approach.

3 – The results are used in management and in setting policy priorities. The SIS has a measure of influence.

3. System Features

Does the SIS take into account the significant attributes and policy features of sustainability research and environmental management? These issues need to be considered for SIS effectiveness and are considered core elements of the sustainability debate. As discussed by Dovers (2001) problems in sustainability have attributes that render them particularly difficult and different from other policy fields (discussed above in 3.2.1). A core element of sustainability decision making is the approach taken to incorporate uncertainty into decisions, especially within a climate of limited information. Therefore, it logically follows that an indicator system must take account of these uncertainties and develop approaches that lead to improved assessments and decisions. These approaches are called ‘System Features’ and are divided into the criteria of *integrative capacity, adaptive management, participation and project management.*

3a Integrative Capacity.

Does the SIS demonstrate an integrated approach to resource management? Effective indicator systems should address the multiple dimensions of sustainability, take a holistic focus and relate to broader policies (Charles 1997; Charles 1998a). This maintains the relevancy and effectiveness of the system in a broader socio-economic and political context. In terms of fisheries, sustainable management recognises the need for the inclusion of socio-economic and cultural influences into management (Daly 1995; Bowen 1996; Bonzon 2000; Berkes et al 2001). In reference to criteria 2b (dimensions of the SIS) this score relates to the notion of the SIS capturing an ‘integrated system’ and references within the SIS that measure, define and acknowledge interactions between ecosystem and human components. This criteria also refers to the SIS ability to integrate reporting within and between sectors and focus interdisciplinary research (Moldan 1997; Bell & Morse 1999; Dovers 2001). Ensuring clear connections between global and regional policies to operational activities is an important concern (FAO 1995; Caddy 1999; Garcia 2000; Ward et al 2002).

Interaction of Sustainability Dimensions

Does the SIS attempt to assess the inter-related nature of sustainable development? Are socio-economic, ecological and institutional factors considered in an integrated fashion? The reality of systems as an interplay of complex factors should be represented in the SIS.

0 – No recognition of inter-related nature of SD. Single focus. Static.

1 – Interactions are recognised, no indicators or mechanisms for assessment.

2 – SIS developing tools and processes that take into account multiple interacting dimensions.

3 – Multiple dimensions explicitly recognised with formal integrative models & mechanisms.

Integration with other reporting systems and sectors.

Does the SIS have links to, or feed into broader reporting systems and regional / global policies? Does the SIS facilitate reporting amongst and across the sectors?

0 – No integration with other reporting systems / policy. No linkages within / across sectors.

1 – Vague links to broader reporting / policy. Minimal links within and outside of sector.

2 – SIS feeds into reporting systems outside the fishery and across multiple fisheries.

3 – SIS has formal processes for cross reporting within the sector, between sectors, at different scales. Explicit recognition of regional / global policies.

3b Adaptive management.

This feature, related to the input process, incorporates ongoing strategic research within the SIS and the ability to incorporate this information within the system. Adaptive management is cited as a critical element in SIS and the institutions employing them (Charles 1994; Dovers 2001) especially within a climate of uncertainly. Does the SIS recognise and use adaptive management techniques to assess sustainability (Charles 1994)? Does the system addresses mechanisms required to collect information and establish management approaches (Charles 1994; Bell & Morse 1999; Jessinghaus 1999; Dovers 2001).

Social and institutional indicator development.

Research suggests lack of social and institutional / governance indicators in fisheries. Does the SIS promote or use new data on these indicators and performance measures.

0 – No use or recognition of socio-economic / institutional indicators.

1 – Recognition of socio-economic dimensions or criteria but minimal use of indicators to assess these issues.

2 – Basic use of indicators, ongoing research, development, and monitoring. Socio-economic issues are recognised and the SIS is improving it measures.

3 - Well developed and promoted socio-economic / institutional indicators. An innovative approach.

Adaptive management approaches.

Regular reviews of the aim, scope, and performance of the SIS and incorporation of this information back into the management process is necessary for adaptive management. Does the SIS employ an external monitoring and review process? Linked to input process.

0 – No review or monitoring process. No gathering of new information.

1 – Monitoring program proposed, no results.

2 – Informal monitoring of SIS and feedback.

3 - Formal review and monitoring of SIS is performed. New forms of information are included in the SIS.

3d Participation

Representation and participation facilitates an open transparent process, and 'buy-in' from users (Hardi & Zdan 1997 ; Bossel 1999). Adequate participation reflects the diverse nature of issues from a cross section of society that is to be addressed in an assessment, and avoids the myopic short term needs of single interest groups (Hardi et al 1997 and Dovers 2001). It may also limit disputes and may reduce the level of litigation and misunderstanding (Jessinghaus 1999). Without such participation the identification of issues and concerns and implementation of solutions becomes more difficult, especially when the resolution is beyond the capacity of a single sector or government department (Hardi et al 1997). Such components increase the effectiveness of the SIS.

Participation of stakeholders

Facilitates ownership and buy-in of the process. The SIS involves full participation of all relevant stakeholders – including but not restricted to: commercial, recreational, management, conservation, and indigenous interests.

0 – No perceived participation or input from stakeholders. Top down approach. Conflict.

1 – Minimal participation by stakeholders in SIS development & application.

2 – Stakeholders consulted through an informal process. Top down process.

3 - Full open, regular participation. Stakeholders defined and included. Mix of bottom up and top down approaches.

Participation of decision makers and institutions.

0 – SIS does not appeal, lacks power, single institution focus.

1 – Minimal participation. Single institution.

2 – Increased influence, linkages exist for SIS results into decision tools.

3 - Decision makers informed, strong linkages to decision tools. Strong influence on policy.

3e Project Management.

The institutional capacity, organisation, finance, and marketing will influence the effectiveness of the SIS in reporting sustainability (Moldan 1997 and Dovers 2001). These elements are required to harness resources, both financial, administrative and personnel to develop and maintain the SIS. This criteria would be a prime influence on the persistence of the SIS over time (Dovers 2001).

Institutional capacity

Does the coordinating body have the finance, human resources, institutional process and linkages to manage the SIS? Does the organisation have the sufficient skills? Does a steering committee and project planning team exist?

0 – Limited capacity for management. Short term project.

1 – Minimal capacity, resources and linkages. No budget.

2 – Moderate capacity for SIS to be implemented. Small budget and / or resources.

3 - Sufficient capacity and skills. Steering committee and project planning established. The project is well resourced.

Marketing and R&D.

Does the institution market the SIS? Is there an export of the design and benefits to interested users? Is the SIS promoted?

0 – No perceived marketing or export of ideas.

1 – Minimal marketing.

2 – Emerging recognition of the SIS as useful. New ideas presented eg. multimedia solutions.

3 - System widely recognised as useful, design published, ongoing promotion. Innovation.

4. Fisheries specific issues.

This category recognises that to report against sustainability for fisheries, several specific issues must be incorporated into the design of the SIS to make it fishery relevant. The prevalent literature on fisheries sustainability and indicators ahs been harnessed to develop these criteria. The SIS model did not contribute to the selection of the criteria, they were formed directly from the discussions in the literature, including peer-reviewed journals, government reports and conference papers. The criteria cover the critical element of fisheries sustainability that any SIS should account for in an assessment. While certainly more criteria could be added, a limit was imposed on the assessment framework based on the aims of this thesis. The criteria, while generalised, do cover the essential fisheries sustainability issues. The identified criteria include: *ecosystem management, target species considerations, uncertainty, fisheries management, static versus dynamic outlook, context, temporal and spatial considerations, and information requirements.*

4a Incorporates ecosystem based management principles

Ecosystem based management is emerging practice within fisheries management that leads away from single stock, sectoral management to integrating ecosystem concerns and broader socio-economic influences (Hawley 1989; Commonwealth of Australia 1998b; Fisheries 1999; Garcia 2000). A key issue is the practical implementation of the concept (Caddy 1999; Murawski 2000; Kaye 2001). Does the SIS reflect EBM principles within the framework with criteria and indicators? Establishing a SIS will be an operational tool to develop EBM approaches (Ecosystem Advisory Panel 1999; Ward et al 2002).

EBM principles exist within the SIS.

Includes, but is not limited to bycatch, fishery effects on associated and dependent species, habitat concerns ecosystem and trophic interactions.

0 - No EBM principles exist within SIS.

1 - EBM principles present at the higher levels of SIS (ie the definition or dimensions) but not elaborated through criteria, objectives or indicators.

2 - EBM principles are present, use of proxy indicators, ongoing research to implement.

3 - EBM is a core element of management with associated criteria, objectives, indicators and performance measures.

4b Target species information

Target species information is still central for fisheries management (King 1995; Garcia 1996; Caddy 1999). Are indicators developed that reflect the state of the target species (Sainsbury & Sumaila 2003)? Are these indicators used for informing stakeholders and management decisions?

Indicators assess target stock and used in management

0 – No indicators that represent target species considerations.

1 – Proxy indicators for target species – lack of information for an assessment.

2 –Target species indicators are present in the SIS. Emerging use to inform stakeholders as a part the sustainability assessment.

3 - SIS has developed target species indicators that are used in management planning, informing stakeholders and regulating effort.

4c Recognises uncertainty

Uncertainty is present within the stock assessment process and the management process - it is an inherent feature of the resource (Hawley 1989; Charles 1994; Charles 1998a; Caddy 1999, Charles 2002). Indicators attempt to reduce management uncertainty by explicitly highlighting and measuring the influences and pressures in fisheries that are not traditionally present in management (Berkes et al 2001; Charles 2002). The broadening of the reporting and management process is a key feature of the SIS to reduce uncertainty (Charles 1994, 1998b). A difficulty arises in this score from separating precautionary tools in the SIS (such as error assessment or quantitative modelling) from the fact that an SIS is a precautionary tool in itself.

SIS attempts to recognise and /or quantify uncertainty. The SIS is recognised & used as a specific tool to reduce uncertainty.

0 – The SIS does not recognise the issue of uncertainty in fisheries.

1 – Uncertainty is recognised but not directly measured or assessed. Not used as an uncertainty reducing tool.

2 – Uncertainty is recognised and precautionary tools are trialed. The SIS is cited as a potential tool for reducing uncertainty.

3 – Uncertainty is recognised, precautionary approaches are applied eg. Error quantification, information review, participatory approaches. The SIS is directly used as a tool to reduce uncertainty.

4d Identified relationship to fisheries management.

The SIS should relate back to specific fisheries management plans, plans of action or management committees (Charles 1997). The SIS output should be used to inform decision-making and facilitate forward planing (Baker 1996; Chesson et al 1999, Chesson et al 2000). The relationship between the SIS and the relevant management instrument should be articulated in the initial design (Ward et al 2002).

Indicators feedback to fisheries management.

0 – No relationship specified to fisheries management.

1 – Relationship vague, informal.

2 – Processes being developed for interaction between SIS and management planning.

3 - The SIS output feeds directly into management plans or forums (eg. Management Advisory Committees, Stakeholder forums).

4e Static vs. dynamic reporting

Initial environmental reporting focused upon a static ‘snapshot’ approach, that is, the reporting of a resource state at a certain point in time. However the complex, changing nature of the fishery resource and the influences upon its state demand an increasingly dynamic view of the fishery (Garcia 2000). Does the SIS include information of state and flows of the resource and its influences? Several approaches available that examine the dynamic nature of the fishery including regular feedback reports, fuzzy logic approaches, vectors and resource flows (Ward et al 2002).

Static and dynamic reporting within the SIS.

0 – No examination of the dynamic nature of fisheries. Static ‘snap shot’ approach.

1 – The issue is recognised but no approaches developed to date.

2 – SIS is developing approaches to examine stocks and flows.

3 – SIS uses innovative processes to examine dynamic nature of the fishery and influences, including reporting on stocks and flows.

4f Context Sensitive

The SIS must adapt to context relevant fishery conditions to be meaningful to users and managers within the fishery (Berkes et al 2001). At the lower scale of reporting (ie. local, provincial and sub national) context sensitivity will encourage ownership, relevance and information input. As reporting moves to higher scales (national, regional and international) local relevance will be reduced, as broader indicators are required (Bell & Morse 1999). The literature suggests that context sensitive systems are the most useful for reporting fisheries sustainability (Garcia 2000; Fletcher 2001; Des Clers & Nauen 2002).

Does the SIS take fishery specific contextual issues into account?

0 – SIS does not assess specific fishery issues or operations (eg. gear).

1 – SIS has minimal context relevance – maintains a broad focus.

2 – The SIS has context relevance. It is relevant to the fishery unit.

3 - The SIS has direct context relevance (ie directly with the fishery). The SIS measures fisheries relevant issues and is linked to broader frameworks for reporting.

4g External influences – broader socio-economic indicators.

The SIS should contain and refer to information and indicators on broader socio-economic concerns and external influences, for example overcapacity, illegal, unreported and unregulated fishing, harmful subsidies, trade, coastal degradation and development and pollution. External influences represent significant forcing factors on the fishery and should be monitored in any sustainability assessment (Staples 1996; Perrings 2000; Arbour 2001; Des Clers & Nauen 2002).

Other relevant issues of an external nature

0 – No recognition of external influences.

1 – Minimal recognition of external influences – no state indicators.

2 – Developmental approach. Influences identified and research ongoing, use of proxies or developmental indicators.

3 - SIS incorporates external influences and relevant indicators and performance measures.

3.4 Case Studies and Synthesis

(Hyatt 1999) recommends examining a variety of cases to understand the complexities involved in the use of environmental indices – this method is used to evaluate the complexities of using SIS in fisheries systems. Several case studies have been identified that represent the use of indicator-based systems across fisheries jurisdictions. Cases have been selected from national jurisdictions, at the regional (multi-lateral) scale including areas under common management on the high seas, and from the emerging non-government/private sector. Each case contains an indicator system that attempts to assesses the sustainability of a fisheries system. As discussed in previous chapters, the interpretation of sustainability within the fisheries context can take many forms and meanings. This leads to a cross section of potential cases across a range of jurisdictions. The aim of the research is to investigate a spectrum of applications and generate conclusions over the ability of SIS to achieve sustainable outcomes. It is on this basis 10 case studies have been selected, shown in Table 7 below.

This thesis takes a selection of cases from a variety of jurisdictions. Two primary criteria were used for the selection of the cases.

The first criteria is the selection of cases from jurisdictions that are involved in managing fisheries and implementing indicators. Cases were selected from national, regional (international) and non-government/private jurisdictions. The mix of jurisdictions highlight how SIS can be applied across the board in diverse management scenarios.

National jurisdictions (cases 1 to 8) make up the balance of case studies. Primarily fisheries are regulated by national and sub-national authorities, with the Law of the Sea Convention 1982 establishing many stocks under national control. The majority of fisheries today are managed under some form of national jurisdiction, and at provincial, subregional and/or local units. Many indicator based initiatives are developing at the national level across the globe. These range from fishery specific approaches to broader ‘state of the environment’ type approaches. Chapters 4,5 and 6 explore national jurisdictions in detail.

Table 7: Case Studies

Case Study	Jurisdiction	SIS
Australia	National	(1) State of the Environment Report (2) Environment Australia Strategic Assessments for Fisheries (3) NRMC ESD Reporting Framework
Canada	National	(4) National Environment Indicator Series (5) NRTEE Sustainable Development Indicators Initiative (6) Objectives Based Fishery Management (7) Traffic Light Method
New Zealand	National	(8) Environmental Performance Indicator program.
CCAMLR	Regional	(9) CCAMLR approach to Ecosystem-based management.
Marine Stewardship Council	NGO	(10) The MSC Principles and Criteria for Sustainable Fisheries.

Outside national jurisdiction, several high seas fisheries are managed by regional organisations, or Regional Fisheries Management Organisations (RFMOs)(Case9). International law is currently defining the role of RMFOs, as high seas resources are being fished and pressure is increasing on high seas stocks. National jurisdictions and regional organisations represent a high proportion of fisheries management organisations. Regional fisheries management is explored in detail in Chapter 7.

The non-government and private sector (Case 10) is rapidly emerging as a new and powerful force in fisheries management. While not directly responsible for the regulation of fisheries, they are without doubt highly influential on the formation of policy and decision making. Certification and eco-labelling schemes are a recent development in the fisheries sector and are influencing the direction of several key national and international fisheries. The non-government certification sector is explored in Chapter 8.

The second criteria for case selection was the capacity of each jurisdiction to implement a SIS and provide sufficient information to allow for analysis against the assessment framework. In the national jurisdiction, case studies were selected from Australia, Canada and New Zealand. These Commonwealth and Federalist countries contain significant features that render them suitable as case studies. These nations all have major fishing industries that contribute to significant domestic supply and international exports. These countries maintain sophisticated fisheries management systems, regulations and policies. In particular, these countries have been the first to embrace the development of Oceans Policies that aim to integrate sustainable marine use in their respective EEZ's. Most importantly, Australia, Canada and New Zealand are relatively experienced in the development of sustainability indicator systems that relate to fisheries management and can be considered progressive in this field. Within each national jurisdiction, a mix of mature and developmental indicators systems were found with sufficient information for analysis.

In terms of the regional jurisdiction, the case selected was the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR). CCAMLR was the first organisation to explore and implement the notion of ecosystem based management in fisheries during the 1980's. It has had significant experience in applying the ecosystem concept to fisheries management and is relatively advanced in terms of exploring the use of indicators in a management context. CCAMLR, as a RMFO, faces particular issues in the management of high seas resources, including increased pressure on stocks and illegal fishing. Information on the ecosystem approach and application of indicators is readily available and adequate for analysis via the assessment framework.

For the non-government jurisdiction, the Marine Stewardship Council (MSC) initiative is proposed as a case study to highlight the use of an indicator based system to achieve sustainability outcomes. The MSC has developed a rigorous, indicator based approach to assessing fisheries systems that forms the basis of a certification program. The MSC approach is a unique attempt at using market-based mechanisms and 'consumer power' to alter fisheries management towards sustainability. Its is engaging fishers, processors, suppliers and consumers and has already certified several large international fisheries. Information about the MSC process and certified fisheries is available for analysis. Therefore, the MSC represents an optimal case for examining the use of indicator systems within fisheries.

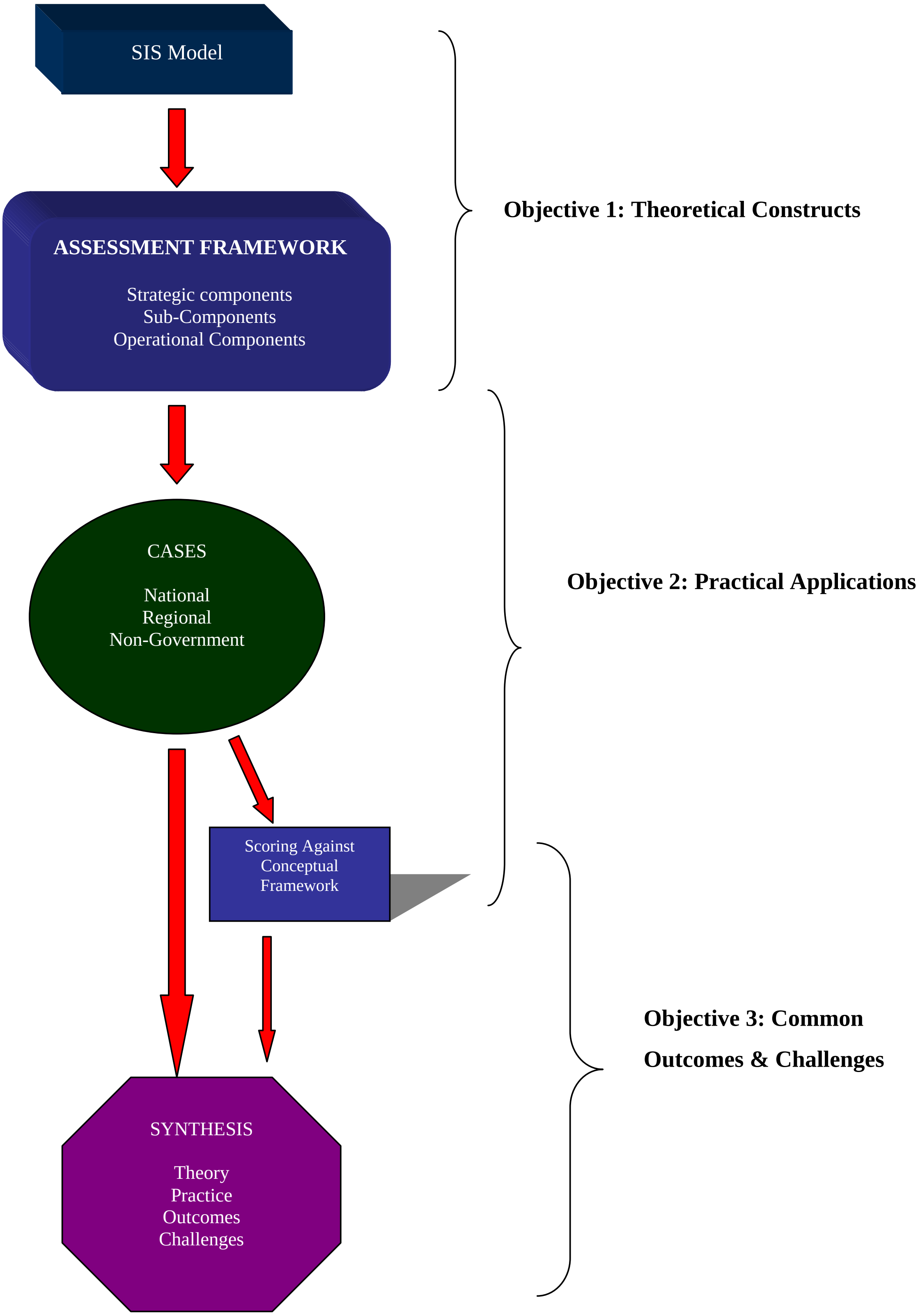
Each case study follows a template to allow for clear presentation of information. The template contains the following information.

- Case study introduction and summary.
- The policy framework for the implementation of sustainability.
- The fisheries management framework
- The relevance of the case to the thesis
- Background, structure and status of the indicator system.
- Scoring, orientation graphs and analysis of the sustainability indicator system against the assessment framework.

To compare the performance of each case study, a series of matrices have been developed to examine the common structures, processes and application issues as identified in the thesis aims.[87] In addition, a ranking of the case study results will be performed under the method established by the Dashboard of Sustainability (Jessinghaus 2003). This tool aggregates and ranks the cases, and was adapted to apply to the results of the case studies from the assessment framework. The total aggregate performance of the SIS can also be calculated from the Dashboard. The method allows for a visually innovative approach of comparing the results from the case studies and facilitates discussion on the structures and processes that underlie SIS, their application in fisheries contexts, and their overall role in operationalising sustainability. The overall framework of analysis for this thesis is summarised in Figure 14 and displays how each step of the research relates to the thesis objectives.

[87] The summary matrix will be presented in the Synthesis Chapter.

Figure 14. The Framework of Analysis schematic.

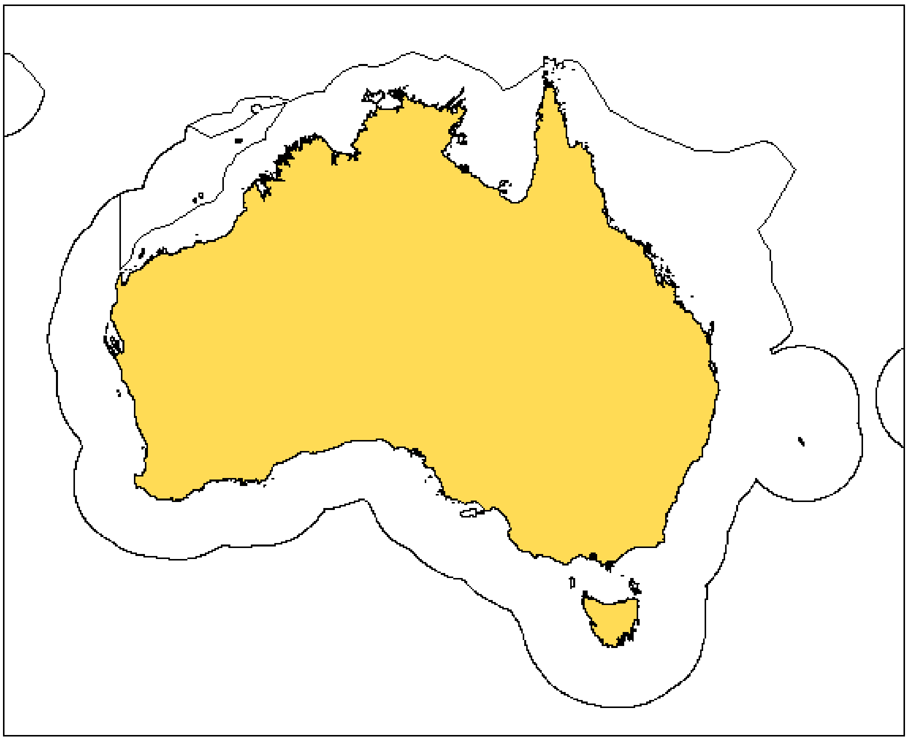


Chapter 4: National Approaches
Case Study: Australia

4.1 Introduction

Australia has responsibility for the third-largest maritime jurisdiction in the world (Commonwealth of Australia 1998a; BRS 2000). The exclusive economic zone potentially covers 11 million square kilometres of ocean with the claimable continental shelf region adding a further 5.1 million square kilometres of oceanic territory (Figure 15). [88]

Figure 15: Australia's Exclusive Economic Zone (External Territories not included) (AFMA 2003).



Fisheries occur in a wide diversity of marine environments: estuaries, coastal waterways, near shore waters, deep oceans and sub-Antarctic waters. Fishing and aquaculture is the fifth most valuable Australian industry after wool, beef, wheat and dairy (Agriculture 2002). Although Australia ranks about 50th in world fish production in tonnage, Australian fisheries target high market value species such as prawns, lobsters, abalone, tuna and billfish (Australia 2000).

[88] The claimable continental shelf zone applies to non-living seabed resources and not marine living resources.

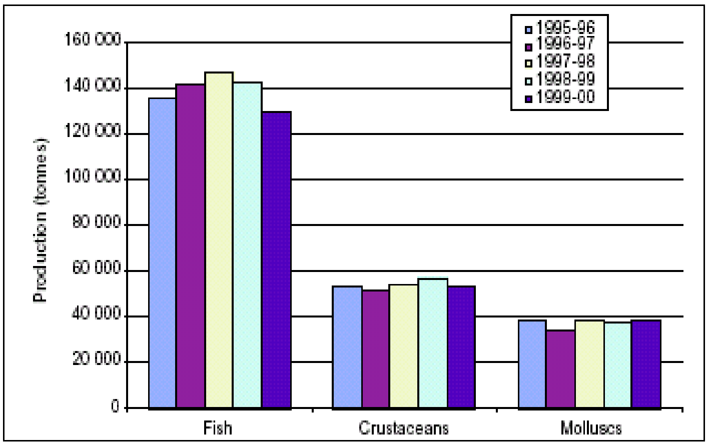
Australia is also developing a distant water fleet capacity (Yuile 2000). Aquaculture is playing an increasing role in production with a significant increase in the level and value of operations in the last decade (Australian SoE Committee 2001; Haward 2002). There has been a significant increase and diversification of aquaculture species farmed in Australia due to a diverse climate and isolation from disease (Australian SoE Committee 2001). Of the approximately 60 different species farmed, the major contributors are: pearl and edible oysters, Atlantic salmon, prawns, and farmed Southern Bluefin Tuna (ABARE 2000).

4.1.1 Overview of Australian Fisheries

In 1998 –1999 the gross value of Australia's fisheries production, including aquaculture, was \$2.04 billion (ABARE 2000). In 2000-2001 production rose 13% to 2.32 billion (Larcomb et al 2002). Preliminary statistics indicate that the gross value of seafood production in 2000-01 has reached A\$2.48 billion and is expected to reach \$5 billion by 2020 (Haward et al 2002). Figure 16 below details the production of Australian fisheries by major species groupings and tonnage. Fish species make up a significant proportion of the total catch at 63% or 143 196 tonnes. Crustaceans and molluscs form 24% or 55 570 tonnes and 13% or 30 053 tonnes respectively. In terms of value crustacean and mollusc fisheries are lucrative providing 64% of total value and 77% of export value.

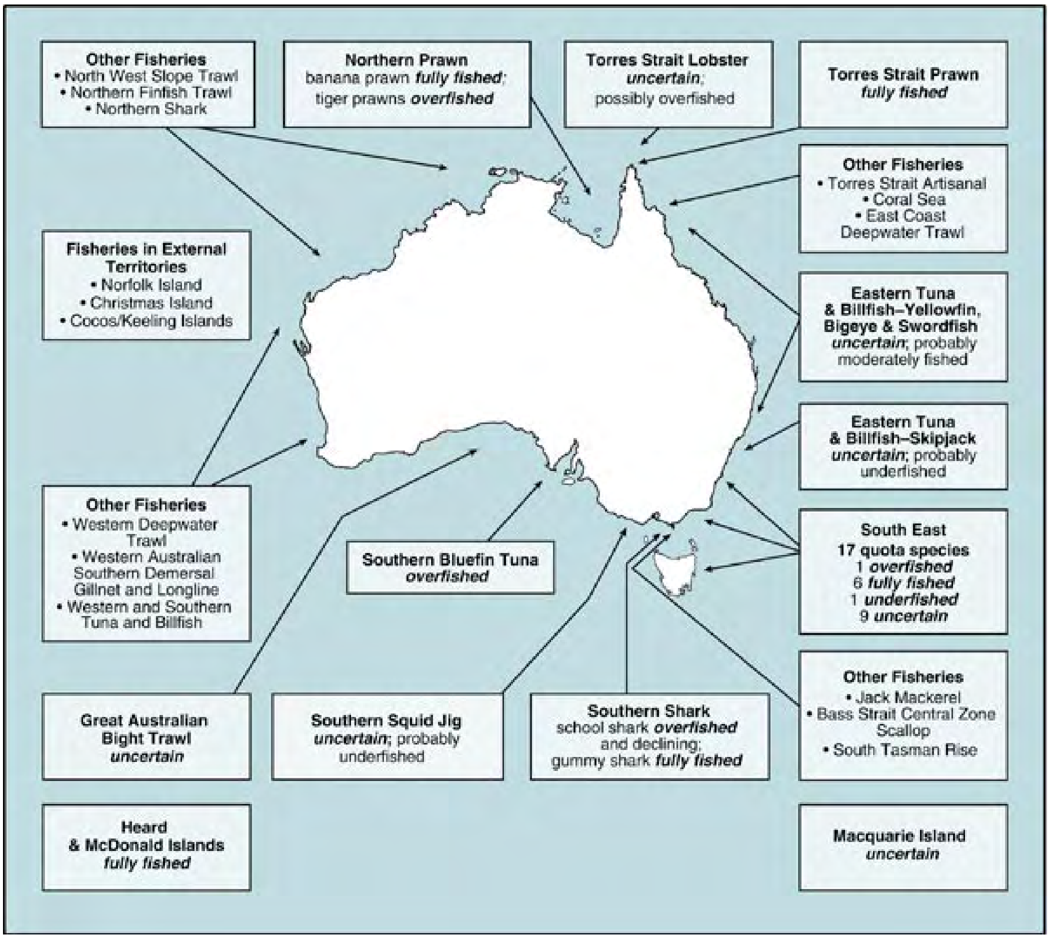
Fisheries are an important source of employment for marine and coastal communities in regional Australia (Larcomb et al 2002). There are about 9,000 commercial fishing boats in Australia and direct employment in the catching/harvesting sector is around 21,000 people. In addition 4,000 are employed in processing (Agriculture 2002).

Figure 16 Australian fisheries production from 1995–96 to 1999–2000 (Australian SoE Committee 2001).



Most major Australian fisheries are considered ‘fully fished' if not over exploited (Australia. 2000; Australian SoE Committee 2001; Potts 2001). For Commonwealth managed stocks 4 are overfished, 10 are fully fished, one is under fished, and the status of 15 is uncertain [89] (Australia 2000). The Commonwealth fisheries that have overfished status include the Southern Bluefin Tuna, school shark, tiger prawn and Eastern Gemfish stocks (Australia. 2000; AFMA 2002). These species are also caught in the State-managed fisheries. Figure 17 below highlights the location of the major Commonwealth fisheries.

Figure 17. The Commonwealth Fisheries and Status (Australian SoE Committee 2001).



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[89] According to Australia (2000) stock status classifications are defined as:
Fully fished: a stock for which current catches are close to optimum sustainable levels (definition can vary between fisheries). Increase in effort may lead to overfishing.
Overfished: A fish stock for which levels of fishing or catches are excessive, or reflects the effects of prior excessive fishing.
Underfished: A fish stock that has potential to sustain catches higher than those currently taken.
Uncertain: A fish stock that may be underfished, fully fished, or overfished but inadequate or inappropriate information to assess status.

As a result, conservation related issues have emerged as core considerations within fisheries management and have been the focus for several important policy developments in State and Commonwealth fisheries agencies (Chesson 1999; Fletcher et al 2002). In response to the growth of these issues a number of innovative management strategies including the development of indicator systems have emerged.

The core environment-related issues that currently face Australian fisheries include (Australian SoE Committee 2001; Haward et al 2002, AFMA 2003b):

- The management of effort and activity to minimise the impact upon benthic and pelagic ecosystems and maintenance of ecological sustainability;
- The sustainable management of target species (including improved scientific information).
- The reduction of impacts on non-target (bycatch) species removed or injured during fishing activities. This includes the impacts upon significant endangered species such as turtles, sharks and seabirds that are caught or killed incidentally by fishing activities.
- The impacts of marine pests on the environment.
- The effect of land based pollution and coastal development upon inshore nursery habitats, for example, mangrove destruction.

These issues have alone influenced the development of fisheries policy in Australia. However, in addition to these environmental issues, the influence of integrated socio-economic and governance approaches is emergent (Ward 2000). These issues have traditionally been placed behind environment issues in priority or not seen as a part of the management mandate. However with sustainability increasingly seen as an integrated approach, these issues are identified as important considerations in sustainability reporting (Larcomb et al 2002).

The sustainable development of marine resources is an accepted policy goal that has been legislated into the majority of fisheries management and environmental regimes within Australian jurisdiction (Chesson 2000). Several trends have become apparent over the management of Australian fisheries resources:

- Increased awareness from the community, government and private sectors of the importance of incorporating sustainability into management [90];
- Awareness of the broader and specific economic, social and ecological pressures within fisheries and how they interact; [91]
- Research and awareness of ecosystem based management and precautionary approaches in addition to single stock approaches;
- The development of innovative reporting processes that attempt to capture the above considerations.

This case study documents and evaluates the recent developments within Australian fisheries management that report, measure and assess sustainability. These systems have evolved under increasing community and government pressure to assess fishery performance under sustainability principles, and account for ecosystem-based and socio economic concerns in fisheries management.

4.2 The Policy Framework for Sustainable Development in Australia

Australia has developed several broad policy and legislative initiatives for guiding the implementation of sustainable development at the Commonwealth level and for facilitating agreement and coordination with the states.[92] Australia is also a signatory to many international agreements and treaties that implement international sustainable development and environmental policies. [93]

The Commonwealth of Australia is a federation of six self-governing states and two self-governing mainland Territories. The Commonwealth Government's powers and responsibilities are defined in the Australian Constitution. [94] With environmental powers spread across

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[90] Increased awareness has been generated following various initiatives and key events at domestic and international levels. UNCED in 1992 gave impetus to Governments, non-government bodies, and industry to develop initiatives that promote sustainability in fisheries. See Commonwealth of Australia (1992); Commonwealth of Australia (1998b_; Australia, (1998b).
[91] Refer to Australia (1991b); Daly & Erlich (1995); Gill (1999); and Hundloe (2000).
[92] This section highlights the relevant national and intergovernmental instruments for implementing sustainable development at a Commonwealth and inter-governmental level.
[93] See Herriman et al (1997) and CIESIN (1998) for international treaties and bilateral agreements that Australia has signed and ratified.
[94] The Constitution does not have direct powers for environmental management. However through its designated powers to legislate with respect to corporations, external (foreign) affairs, input, export and quarantine, and control of fiscal matters in relation to state spending, the Commonwealth can regulate and influence environmental activities and generate legislation to fulfil these duties. Despite these powers, the States control most of the regulation and management of environmental activities including national parks,

Commonwealth, state and local agencies environmental management is often fragmented and uncoordinated between jurisdictions (Commonwealth of Australia 1991b).

The Commonwealth government has focused on a consultative approach to implementing sustainable development. It has investigated and developed several inter-governmental initiatives to facilitate governance with state authorities and improve the coordination of decision making in regards to sustainable development (Productivity Commission 1999). This approach extends to non-governmental organisations and community groups. The effect of such initiatives is to reduce the possibility of duplication of policy decisions and to promote consistent application of sustainability indicators. Despite the intent, however, several intergovernmental initiatives have been poorly coordinated and implemented, with many large-scale, jurisdiction-crossing, environmental problems still occurring throughout Australia.[95]

In 1990 the Commonwealth, states and territories negotiated the Intergovernmental Agreement on the Environment (IGAE). The IGAE was signed by the Commonwealth, states, territories and local government in 1992 (COAG 1992). The IGAE aimed to define the roles of each level of government, reduce intergovernmental environmental disputes, provide greater certainty in government and business decision-making and provide environmental protection[96] (COAG 1992). The agreement confirms that the states have jurisdiction on most matters of environmental significance but the Commonwealth plays an important coordinating and standard setting role (Productivity Commission 1999).

The National Strategy for Ecologically Sustainable Development (NSESD) is the cornerstone of Commonwealth sustainable development policy. The national strategy was preceded by a series of Ecologically Sustainable Development working groups that focused on sectoral and cross-sectoral issues (Commonwealth of Australia 1991a; Commonwealth of Australia 1991b). The resulting NSESD covers a number of key industry based sectors that rely on natural resources and also identifies strategies for a range of cross-sectoral issues such as biological diversity,

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land management, agriculture, fisheries, pollution control, waste management and other areas of relevance.

[95] Large scale, intergovernmental problems include salinity, the Great Barrier Reef, and water rights. At this point in time, inter-governmental mechanisms have failed to reduce or comprehensively address these issues.

[96] The IGAE sets out four main principles to inform policy making (COAG 1992):

- The precautionary principle - where the threat of environmental damage is serious or irreversible, a lack of scientific proof of damage is not a defence against action to prevent the degradation;
- Inter-generational equity - the health of the environment should not be eroded for the benefit of the present generation at the expense of future generations;
- Conservation of biological diversity and ecological integrity; and
- Improved valuation, pricing and incentives for conservation.

environmental impact assessment, pricing and taxation, and changes to government institutions and policy process (Commonwealth of Australia 1992 & Productivity Commission 1999).

Until 1997 the Intergovernmental Committee for Ecologically Sustainable Development was responsible for reviewing progress and reporting to the Council of Australian Governments (Oakley 1997). It reported once, in 1996 but was disbanded in 1997. The Productivity Commission completed a detailed report in 1999 on the Commonwealth Government's implementation of sustainable development by government agencies (Productivity Commission 1999) No further reviews have taken place to date.

In 1999 the Commonwealth government completed a major overhaul of environmental legislation. The Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) entered into force in July 2000 (Commonwealth of Australia 2002b). The EPBC Act provided domestic effect to the Biodiversity Convention and the Jakarta Mandate [97]. The Act gives the federal environment department, increased powers for environmental protection for matters of 'national significance'[98], manages the environment on Commonwealth land, regulates the actions of Commonwealth departments, and contains management and assessment functions. The EPBC Act promotes sustainable development principles in Section 1 (Commonwealth of Australia 2002a) but does not go further to set a working definition. The Principles refer to integrated decision-making, the precautionary principle, inter-generational equity, conservation of biodiversity, and improved valuation and incentive mechanisms for conservation.

Other key strategies which have been implemented since 1992 include the National Forest Policy Statement, the Regional Forestry Agreements, the National Strategy for the Conservation of Australia's Biological Diversity, the National Greenhouse Response Strategy, the Commonwealth Coastal Policy, the National Waste Minimisation and Recycling Strategy, and the National Landcare, Rivercare and Coastcare Programs (Committee 2002).

4.3 Management of Fisheries and the Marine Environment

In terms of marine management, the states and territories have jurisdiction over areas 3 nautical miles from the identified baseline, and the Commonwealth, through the Australian Fisheries

[97] The EPBC Act replaces the following Commonwealth legislation: Environment Protection (Impact of Proposals) Act 1974, Endangered Species Protection Act 1992, National Parks and Wildlife Conservation Act 1975, World Heritage Properties Conservation Act 1983, and Whale Protection Act 1980 (Commonwealth of Australia 2002a).

Management Authority (AFMA) has jurisdiction beyond those waters to the outer boundaries of the EEZ (Rothwell 2001; AFMA 2003). The resolution of jurisdictional conflicts between the Commonwealth and the States for marine management was entrenched through the conclusion of the Offshore Constitutional Settlement in 1983 (Haward 1989; Rothwell 2001).

The Offshore Constitutional Settlement (OCS) incorporates arrangements between the Commonwealth and the States relating to management of marine resources (oil, gas and other seabed minerals), fisheries, the Great Barrier Reef Marine Park and other marine protected areas, historic shipwrecks, and ship-sourced marine pollution (Haward 1989). The arrangements in the OCS were designed to 'rationalise' fisheries management and enable either the state or Commonwealth to manage individual fisheries over the 200-mile fishing zone (Rothwell 2001).

The Commonwealth policy statement, New Directions for Commonwealth Fisheries Management, was released in 1989. The policy established the legislative basis for modern Commonwealth fisheries management (Commonwealth of Australia 1989; AFMA 1999). The policy was 'based on the need for the ecologically sustainable development of fisheries resources' and the integration of objectives to achieve effective management (Commonwealth of Australia 1989). The policy led to the establishment of the Fisheries Management Act 1991 and the independent statutory body, the Australian Fisheries Management Authority.[99]

AFMA has been established as an independent management agency that is external to (but works closely with) the Department of Agriculture, Fisheries and Forestry Australia (AFFA). [100] The AFMA model is based on (AFMA 1999):

- The organisations operational independence from the Minister;
- A strong partnership approach with industry and stakeholders through a management advisory committee approach;
- Accountability provisions (the Minister must approve the annual corporate and operational plan and each fisheries management plan); and
- Establishing user rights for the fishing industry.

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[98] Matters of national significance include World Heritage properties, Ramsar wetlands, threatened species and communities, migratory species, nuclear activities and Commonwealth marine areas Ibid.
[99] The policy also led to the development of Fisheries Administration Act 1991, Fisheries Agreements (payments) Act 1991, Fishing Legislation (Consequential Provisions) Act 1991, Fishing Levy Act 1991, Foreign Fishing Licences Act 1991, and Statutory Fishing Charge Act 1991. The Fisheries Management Act was amended in 1999 to give effect to the UN Fish Stocks Agreement and provide an improved legislative basis for IUU fisheries action (Haward *et al* 2002).

The legislative objectives for AFMA are set out in Section 3 of the Fisheries Management Act 1991(Commonwealth of Australia 1991)[101], as amended.

A significant shift in the policy basis for fisheries management was the development of Australia's Ocean Policy in the International Year of the Ocean, 1998.[102] The policy sets the basis for integrated use of Australia's ocean territory under LOSC [103] and sets a focus on integrated ecosystem-based planning and management; cooperative mechanisms between the states and the Commonwealth; commitment to the precautionary principle; and increased scientific effort in monitoring (Commonwealth of Australia 1998a; Commonwealth of Australia 1998b). The Oceans Policy was initiated by the Commonwealth government (Herr 2001) and applies to activities within Commonwealth waters from 3 to 200 nautical miles. The Commonwealth and state governments are currently engaged in negotiation for further integrated approaches in the marine environment (Herr 2001).

Achieving integrated management across sectors within an ecosystem-based management framework is the cornerstone of the Oceans Policy (Commonwealth of Australia 1998a). The vehicle for implementation is the Regional Marine Planning process based on large marine ecosystems (Commonwealth of Australia 1998a; Commonwealth of Australia 1998b) (Figure 18). The introduction of regional marine planning is a new approach to oceans management in

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[100] AFFA is concerned with policy development and strategic operations for fisheries while AFMA deals with the day-to-day management of Commonwealth fisheries.

[101] The following objectives must be pursued by the Minister in the administration of this Act and by AFMA in the performance of its functions (Commonwealth of Australia 1991):

- Implementing efficient and cost-effective fisheries management on behalf of the Commonwealth; and
- Ensuring that the exploitation of fisheries resources and the carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development and the exercise of the precautionary principle, in particular the need to have regard to the impact of fishing activities on non-target species and the long term sustainability of the marine environment; and
- Maximising economic efficiency in the exploitation of fisheries resources; and
- Ensuring accountability to the fishing industry and to the Australian community in AFMA's management of fisheries resources; and
- Achieving government targets in relation to the recovery of the costs of AFMA.

[102] Preceded by Oceans 2000, which was a major Australian Government initiative, which developed the Australian Marine Conservation Plan, National Representative System of Marine Protected Areas, the State of the Marine Environment Report and the Marine and Coastal Community Network (Herr & Haward 2001).

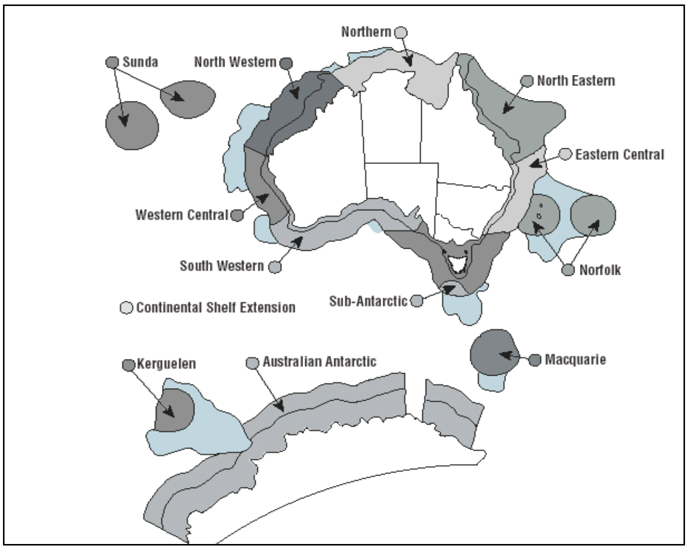
[103] The goals for Australia's Oceans as set out in the policy include (Commonwealth of Australia 1998a):

- To exercise and protect Australia's rights and jurisdiction over the offshore areas, including offshore resources.
- To meet Australia's interaction obligations under UNCLOS and other international treaties.
- To understand and protect Australia's marine biodiversity, the ocean environment and its resources, and ensure ocean uses are ecologically sustainable.
- To promote ecologically sustainable economic development and job creation.
- To establish integrated oceans planning and management arrangements.
- To accommodate community needs and aspirations.
- To improve our expertise and capabilities in ocean related management, science, technology and engineering.
- To identify and protect our natural and cultural marine heritage.
- To promote public awareness and understanding.

Australia. Considerate research has been devoted to ecosystem based and integrated approaches but few practical case studies exist of this form of management (Haward 2001).

The format and delivery of the regional plans, including jurisdictional and decision making processes are in a developmental phase (Herr 2001). The first draft regional plan for the South East region was finalised in 2003 (Haward 2002). In terms of fisheries, existing sectoral regimes for managing these resources will still exist under the Policy, but intend to be integrated at the regional planning scale with other sectors and users of the ocean environment. The Oceans Policy is yet to mature as an intergovernmental instrument with several challenges facing implementation (Herr 2001). A key issue in terms of implementation is the integration of Commonwealth and State environmental and resource policies and 'signing on' of State support. Indeed, as noted in (Herr 2001), State support, sharing of implementation costs and intergovernmental management will be central to Oceans Policy success.

Figure 18. Large marine ecosystem delineation of Australia, identifying Regional Marine Plans (Commonwealth of Australia 1998a).



The development of Australia's Ocean Policy has set the challenge for sustainable fisheries that contribute to the 'social, cultural, environmental, and economic well-being of Australians' (Commonwealth of Australia 1998b). These policy initiatives herald a new focus in fisheries management towards ecosystem-based considerations, multiple-use / marine protected areas and the external assessment of fisheries by environmental authorities. Forty-eight specific policy initiatives are identified in relation to fisheries management, ecologically sustainable fishing practices, economic / regulatory instruments, structural adjustment, recreational use, industry, research, illegal, unregulated and unreported fishing (IUU) and compliance (Haward *et al* 2002). Initiatives of note include the implementation of the National Representative System of Marine Protected Areas, the Commonwealth Fisheries Bycatch Policy[104] and action plans, an intergovernmental National Fisheries Bycatch Policy, and the development of sustainability indicators and strategic assessments.

The development of the Oceans Policy underlies a general shift in the onus of responsibility and broadens the focus for fisheries management. The demand for the review of management performance against ecosystem-based objectives has led to an increasing level of external scrutiny of fisheries practices and management arrangements, principally by environmental agencies. At a Commonwealth level, the EPBC Act now requires an assessment and approval process for activities that are likely to have a significant impact on the Commonwealth marine environment, on nationally threatened species and ecological communities, and on internationally protected migratory species (Commonwealth of Australia 2002b). The most significant development for fisheries under the EPBC Act is the requirement for strategic assessments of Commonwealth and export fisheries against sustainability criteria (Commonwealth of Australia 1998b; Commonwealth of Australia 2002). The development of sustainability assessment approaches within the Australian fisheries sector is the focus of the case study below.

4.4 Sustainability indicator systems in the Australian fisheries sector.

The development of indicator systems for fisheries by Australian governments has been progressive. Indicators have been recognised as important decision-making tools that can assist in informing the public, stakeholders and managers about sustainability. There has been considerable effort devoted to the development of reporting frameworks at sectoral and national environmental scales. State of the Environment Reporting was initiated in 1992 and was the Australian Governments initial foray into assessing environmental sustainability (ANZECC 2000). Over the years policy developments have pressed for an increasingly integrated approach that takes into account the social and economic dimensions, acknowledging that environmental

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[104] The Commonwealth developed a National Bycatch Policy in 1999 and a Commonwealth Bycatch Policy in 2000. The National Policy restricts its attention to non-target discard species and non-target organisms affected by fishing gear, and does not include by-product. The Commonwealth Policy requires AFMA to prepare Bycatch Action Plans for all major Commonwealth fisheries. Plans for the Northern Prawn Fishery and the Torres Strait Prawn Fishery were implemented in 1999 Bycatch Action Plans for other Commonwealth fisheries are in development (Australian SoE Committee 2001).

considerations are an important component, but socio-economic factors drive management response.

The introduction of specific approaches to sustainability within fisheries can be seen as a continuum in policy development as part of environmental, fisheries and oceans management. Increasing awareness by the Australian community over the effects of fisheries on the marine environment has also occurred since the early 1990s. The development of SIS cannot be attributed to one particular event, policy or development, but rather the result of a changing climate of expectation and cumulative pressures over the accountability of fisheries management to sustainability principles. These principles have been embedded in most state and Commonwealth fisheries legislation since the 1992 Commonwealth Strategy for ESD but only recently have the specific concerns evolved for measurement, reporting and accountability via the use of indicators.

The latter 1990s saw the development of specific policies and projects to measure fisheries sustainability and develop indicators.[105] The State of the Environment process was underway with a marine component and internationally the *Code of Conduct for Responsible Fisheries* had publicised broader management concerns (FAO 1995). The Second World Congress on Fisheries was held in Brisbane, Australia in 1996 and specifically contributed to the awareness of assessing sustainability within fisheries.[106] The Commonwealth Bureau of Rural Sciences developed a pioneering framework for assessing sustainability in fisheries and applied this approach to the South East Fishery (Chesson 1998; Chesson 1999; Chesson 2000). The framework provided the basis for the development of sustainability assessments within the Marine and Coastal Committee of the natural Resources Management Committee [107]. Further recognition was generated with the Australian-FAO Technical Consultation on Sustainability Indicators in Marine Capture Fisheries in Sydney in 1999, which produced the Technical Guidelines report (FAO 1999A), a milestone in fisheries indicator development. Finally Australia’s Oceans Policy was pivotal in awareness raising and developing a series of external review mechanisms for fisheries, and putting the sustainability issue back on the political and community agenda.

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[105] The 1990s saw the development of several marine based conservation and management policies. Oceans 2000 was a major Australian Government program which developed the Australian Marine Conservation Plan, National Representative System of Marine Protected Areas, the State of the Marine Environment Report and the Marine and Coastal Community Network (Australia 1996). Despite these initiatives not directly focusing on the development of indicators, they provided an important background for the recognition and education of sustainability issues in the marine environment.

[106] See Baker (1996); Lane and Stephenson (1996); Mace (1996) and Staples (1996).

The development of fisheries-based indicators within Australian government jurisdiction has evolved from broad cross-issue reporting within State of the Environment approaches, fisheries specific policy developments within government departments, and from broader marine and environmental policy developments with the Oceans Policy and the recent EPBC Act 1999. Each system of reporting displays merits and pitfalls, and approaches sustainability from a different viewpoint according to the objectives of the assessments. A key factor in this national approach is the level of duplication between systems of reporting and coordination across government departments with different mandates.

4.4.1 The relevance of the case studies to the thesis

Three sustainability indicator systems (SIS) have been identified from Australian government jurisdictions. These cases represent the most recent methodological approaches to assessing sustainability in fisheries and were identified from literature, Internet and interview-based research with Australian authorities.

Indicator systems within Australia have evolved through a complex process of policy formulation, agenda setting and negotiation between stakeholders. Each case study has a different approach to reporting against sustainability - a direct result of this historical development and perceived outputs. For the purpose of this study each system is scored against the assessment framework.

4.5 Case 1. Australian State of the Environment Report.

4.5.1 Background

State of the Environment (SoE) reporting pioneered the use of indicators in providing information about environmental issues. The National Strategy for ESD recognised the need to provide more quantifiable advice to decision makers on implementing sustainable development and called for the introduction of regular SoE reports. The recent EPBC Act in 1999 has legislated that a SoE be prepared every 5 years (ANZECC 2000). In addition State and local government agencies have a legislative mandate to undertake similar, but generally uncoordinated, SoE reporting initiatives (Mitchell 2002). SoE reporting is a system that aims to deliver the latest information about environmental issues to a broad audience and facilitate improved environmental decision-making (Australian SoE Committee 2001).

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[107] Formerly the Standing Committee on Fisheries and Aquaculture.

ANZECC (2000) identified that SoE has the following features:

- Is scientifically credible.
- Identifies trends and emerging issues in the environment.
- Assesses efforts to deal with environmental issues including performance value and strategic management.
- Is regular and timely.
- Relevant to the goals of Ecologically Sustainable Development.

The objectives for SoE reporting as identified in (Australian SoE Committee 2001) are:

- Provide accurate, up to date, and accessible information about conditions and trends for the Australian continent, surrounding seas, and external territories;
- Increase public understanding of issues related to the Australian environment;
- Provide early warning capacity;
- Report on the effectiveness of policies and programs.

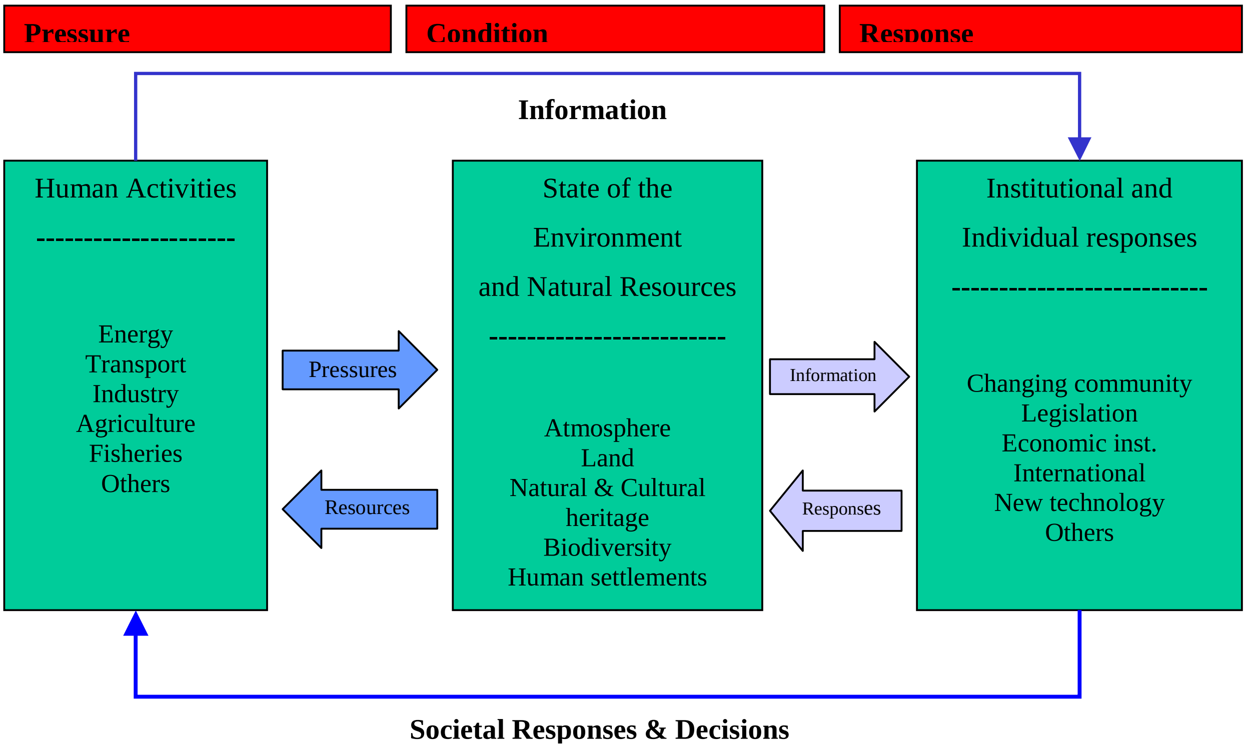
SoE reporting was initiated and discontinued in the 1980s, re-established in 1992, and provided the first national account of the issues facing Australia's environment in 1996. The 2001 report has built upon the findings of the 1996 report and further developed the use of indicators. A significant milestone was an agreement between Commonwealth and State jurisdictions for the development of a core set of indicators for coordinated SoE reporting (ANZECC 2000).

One of the greatest challenges is obtaining reliable data across the range of environmental issues. The 2001 report (Australian SoE Committee 2001) identifies that data and information management are common problems across all reporting themes. Issues included gaps in primary data, access to data, intellectual property and copyright issues and aggregation problems (Australian SoE Committee 2001). Despite these issues, the reports have attempted to make observations regarding important trends and make recommendations. Reviews of indicators are a core part of the SoE process for the next 5 years.

4.5.2 Structure and Indicators

The SoE is structured by means of a thematic and Pressure-State-Response type framework. The SoE Reports are divided into seven theme areas that represent broad environmental issues of concern: human settlements, biodiversity, atmosphere, land, inland waters, natural and cultural heritage and coasts and oceans (Australian SoE Committee 2001). Each theme is presented in a separate report and is based on a number of indicators developed by independent scientific authorities. For each theme the indicators are organised around a modified form of the OECD PSR framework, in this case called the condition-pressure-response framework. Pressure indicators measure activities that affect the condition of the environment, condition indicators represent the status of valued parts of the environment; and response indicators reflect social and institutional responses to altered pressures and conditions. This is summarised in the Figure 19 below. [108]

Figure 19. The Australian SoE Reporting Framework (Australian SoE Committee 2001).



The indicators for Oceans and Coasts are presented in the report *Environmental Indicators – Estuaries and the Sea* (Ward 1998). These indicators form the basis for the 2001 SoE Report. This report identified that there has been little progress in compiling data and information for these indicators at the national scale. This has been a result of restraints on data collection, jurisdictional divisions within and between government, non-government, private and

[108] Elaboration of the PSR Framework can be report found in chapter 3.

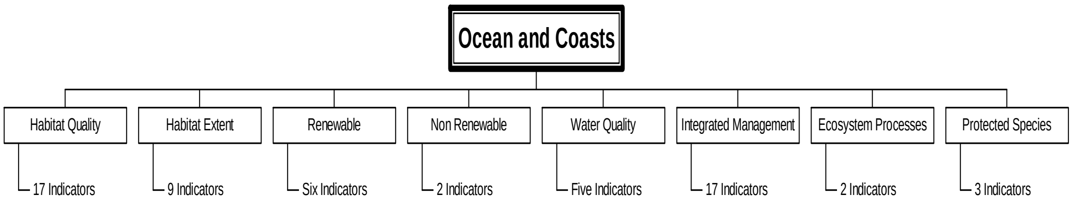
indigenous organisations, and the lack of a national approach to the development of data collection and reporting systems for the marine environment (Australian SoE Committee 2001). The report concedes that considerable further development is needed to assemble, coordinate and use the data that is held in different State and Commonwealth jurisdictions to derive meaningful national scale SoE information and use indicators as decision-making tools.

The Estuaries and the Sea report defines environmental indicators as (Ward 1998;4):

> *…Physical, chemical, biological or socio-economic measures that best represent the key elements of a complex ecosystem or environmental issue. An indicator is embedded in a well-developed interpretive framework and has meaning beyond the measure it represents.*

The report identified eight key criteria and 61 key indicators for reporting on oceans and coasts. The criteria were ecosystems processes, protected species, integrated management, habitat extent, habitat quality, renewable products, non-renewable products, and water quality (see Figure 20 below). A description, analysis and interpretation, monitoring strategy, scale, outputs, and linkages accompany each indicator. In addition, the Biodiversity report contains several indicators of relevance to fisheries (Saunders 1998).

Figure 20. Criteria used in the SoE Report for Oceans and Coasts



Adapted from (Ward 1998)

Indicators from the Estuaries and the Sea and Biodiversity report that relate to fisheries management are identified in Table 8. From the table it can be observed that there are three pressure indicators, nine condition indicators, and five response indicators. The balance of reporting is on assessing the condition of the fisheries and marine environment, which would reflect current data issues in this sector. The table reveals that there is insufficient information on the identified pressure and response indicators. Two of the three pressure indicators were not present in the 2001 report while two of the five response indicators were not present. The lack of indicators, while affecting the overall effectiveness of the report, can reflect monitoring priorities and future research directions.

Table 8 Fisheries relevant indicators from the Australian SoE Report.

Criteria	Indicator and Reference	Condition, Pressure or Response.	Inclusion in 2001 SoE.
Coasts and Oceans			
Protected Species	1.1 Marine Species rare, endangered or threatened	R	Yes
	1.2 Protected Species Populations	C	Yes
	1.3 Seabird populations	C	Yes
Habitat extent	2.7 Mangrove Area	C	Yes
	2.9 Seagrass area	C	Yes
Habitat quality	3.6 Fish Populations	C	Yes
	3.10 Seamount populations	C	No
Renewable Products	4.3 Fish Stocks	C	Yes
	4.4 seafood quality (contamination)	C	Yes
	4.5 trawl fishing area	P	No
	4.6 fishing gear	P	No
Integrated Management	7.8 Fishing effects on non target biodiversity	R	Yes
	7.9 Integration of management	R	No
	7.12 Marine Protected Areas	R	Yes
	7.13 Commonwealth Marine Mgt	R	No
Biodiversity			
	2.1 Extent of clearing and degrading marine habitat	P	Yes
	2.2 Location and configuration or fragmentation of marine habitat	C	Yes

Adapted from (Ward 1998)

4.5.3 Status

The SoE reports have been published in 1996 (Australian SoE Committee 1996) and 2001 (Australian SoE Committee 2001). The EPBC Act legislates that a report must be prepared every five years (Commonwealth of Australia 2002a). The reports do not target specific fisheries; rather a national approach is pursued on marine environmental issues that include a fisheries component, including case studies. The major problem of this national approach, as identified in the 2001 report, lies in the difficulty of obtaining coordinated information at a national level on intergovernmental fisheries issues and applying this information to the report.

4.5.4 Scoring against the assessment framework

The scoring of Case 1 against the analytical framework is presented in Table 9 below. As discussed in Chapter 3, a series of orientation graphs have been prepared from calculating the mean of each set of operational criteria under the sub-criteria headings (Figures 21 a-e). In addition an overall aggregate score has been generated. The figures and analysis are presented below.

In terms of Strategic Outcomes, this case scores low (1) on its approach to understanding the focus system but obtains a high score (3) on its broader contribution to other dependent systems. The scores represent the SoE approach to reporting a range of environmental issues across a national context. The SIS examines a wide cross section of issues with minimal in depth analysis. This leads to a basic understanding and analysis of fisheries issues, but facilitates a national integrated environmental reporting framework across several sectors.

Under System Processes the SIS displays a high score in the Core Structure (2.5), an above average score in the Core Sub Structure (2) and Input Processes (2) and a below average score in the Output Process (1). The focus on a strong definition and framework design in the core structure, a scientifically robust and practical set of indicators, and relevant policy context (through the EPBC Act) in the sub-structure has led to the high scores shown in the figure. In terms of outputs, the SoE approach is relatively weak with basic use of visualisation techniques, no aggregation of scores and minimal influence in direct decision-making. Further integration of the SIS into decision-making and improved use of indicator data will significantly improve the outputs of the SoE approach.

System Features displays a noteworthy trend towards project management with a high score (3) based on the ability of the SIS to be widely marketed to the public and significant institutional capacity for ongoing development. The integrative capacity of the SIS, that is its level of recognising and achieving a holistic approach, has achieved an average score (1.5). The SoE system clearly recognises the integrated nature of issues in fisheries and sustainability, but has not developed methods. The contribution to this score is the fact that SoE does use information from a variety of jurisdictions to report on the environment, and henceforth, does achieve a limited form of integration. Significant areas of improvement for the SIS in this component include developing improved participation by decision makers and stakeholders and developing adaptive management approaches, particularly indicators on institutional and governance measures.

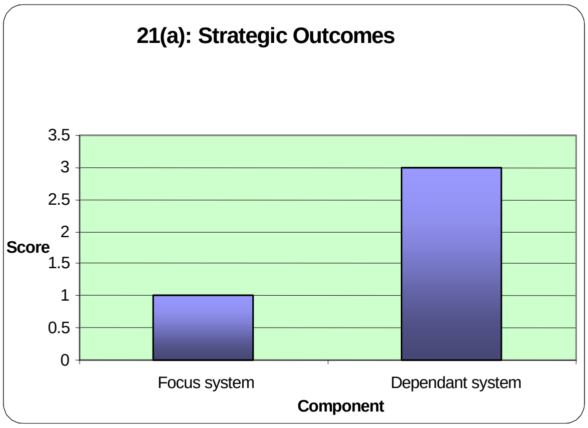
The SoE approach has scored low against Fisheries Issues indicating a weak approach to assessing specific fisheries concerns. The focus of the SIS is on developing information relating to ecosystem based management and target species, despite a general lack of information on these factors. The use of proxy indicators has been developed in the SIS as a means to initiate reporting. Despite the presence of several indicators that are of direct relevance to fisheries concerns, the primary problem in this regard is the lack of data available to construct these indicators. The SoE reports have not included several fishery indicators in recent publications for this reason. Ongoing collection of indicator data is therefore seen as a priority to improve the relevance of the SIS. Improved data collection and use would lead to an improvement of all scores in the Fisheries Issues component.

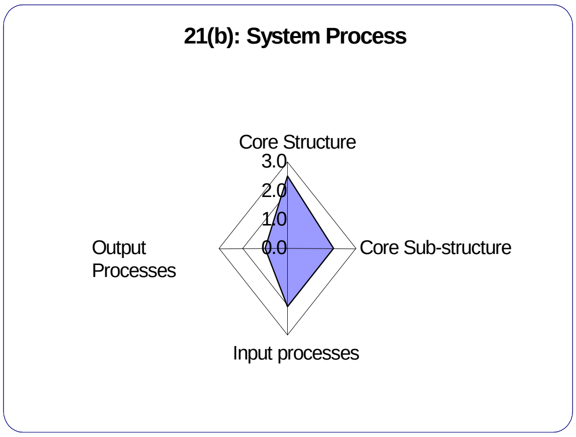
The case aggregate clearly displays average scores in Broad Outcomes, System Processes, and System Features and a low score in Fisheries Issues. This relates to the SIS being focused as a broad reporting tool that covers a wide range of issues and concepts. SoE is based on the premise of being a public education tool designed to give a broad appraisal of the state of the overall environment, and is designed around this approach. It is not designed to specifically fit into a fisheries management regime, but does have the capacity influence the public and affect the decision making process. The improvement in collection of information and its interpretation will directly improve the effectiveness of the SoE approach.

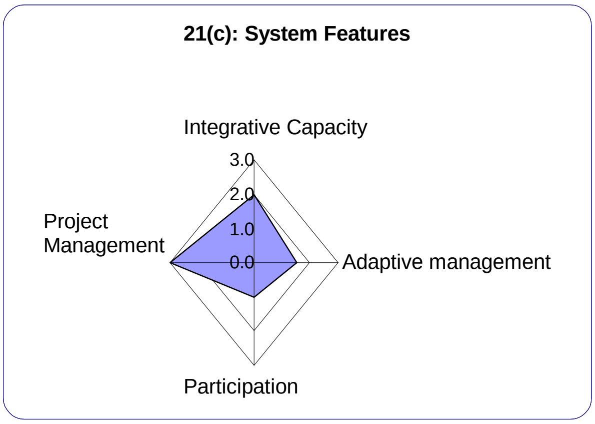
Table 9. Case Study 1 Scoring

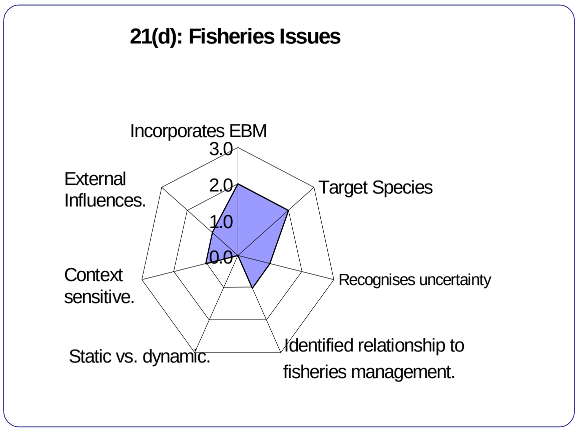
Table 9. Case 1 :State of the Environment Reporting.				
Strategic Objective	*Sub Objective*	*Operational Objective*	*Score*	*Notes*
1. Strategic				
	Understanding the focus system	*System state and viability*	1	Minimal contribution to system state and viability - generalist approach.
	Contribution towards other dependant systems	*System contribution to broader societal sustainability.*	3	Nests within a broad, national environmental reporting framework - all sectors.
2. System Processes				
	Core Structure	*Interpretation and definition of sustainability.*	3	Strong definition, based on National Stategy for ESD.
		Framework classification.	3	Uses the Condition-State-Respone framework. Well established for indicators. Figure 19
		Dimensions of sustainability.	2	Primarily environmental, but increasingly economic & social considerations. Table 8.
		Criteria and sub-criteria.	2	Criteria developed within each reporitng sector, ie. Estuaries & Sea - Cited Taxa / Protected Sp.Table 8.
	Core Sub-structure	*Objectives*	2	Objectives implicit with indicator descrptions and interpretation. Listed in E&S report.
		Indicators: Scientific	2	scientific basis, use of proxies, ongoing research. Lack of information.
		Indicators: Functional	3	relevant, functional and easy to understand.
		Performance values	1	Performance measures for some indicators. PM alluded in analysis and interpretation of indicators.
	Input processes	*Policy context*	3	SoE is a legislated process (EPBC Act) that is used as an independent, public education tool.
		Indicator feedback	2	Review in initial reports. Identified difficulty in obtaining information & monitoring.
		Stakeholder / user feedback	1	minimal feedback, top down approach. No identified feedback process from literature.
	Output Processes	*Visualisation & presentation.*	1	Minimal use of visualisation. Basic graphs.
		Communication & reporting	2	Basic reporting. SoE contains large info base. Link between methods and results unclear.
		Aggregation and scorecards	0	No aggregation or scorecards in reports.
		Decision making influence	1	Minimal regulatory influence. Fullfils role of broad reporting instrument.
3. System Features				
	Integrative Capacity	*Interaction of sustainability dimensions.*	1	Recognition of env / soc / economic dimensions. Further research necessary.
		Integration with reporting systems and sectors.	3	SoE uses the results of seveal national and state reporitng systems.
	Adaptive management	*Social indicator development.*	2	Basic SE indicators developed, but limited data and application.Isue recognised.
		Institutional indicator develop.	1	minimal development
		System monitoring & feedback	2	External monitoring exists by EA. Long timeframe (5 years) between SoE limits feedback.
	Participation	*Participation of stakeholders*	1	Essentially a top down, government pprocess.
		Participation of decision makers and relevant institutions.	1	EA driving the process. Gradual inclusion of info from other departments e.g. AFFA.
	Project Management	*Institutional Capacity*	3	Significant and adequate capacity.
		Marketing and R&D	3	Widely marketed and recognised by the public and stakeholders. Education role.
4. Fisheries Issues				
	Incorporates EBM principles	*SIS reflect broader ecosystem based management principles.*	2	Proxy indicators developed, more data needed for conclusions. Table 8
	Target Species info	*Indicators assess state of the target stock , used in management plans.*	2	Target species included. Commonwealth stocks & limited State info. Ongoing research.Table 8
	Recognises uncertainty	*Assessments explicitly recognise all forms of uncertainty.*	1	Uncertainty recognised but not explicit. Lack of information
	Identified relationship to fisheries management.	*Indicators feedback to mgt.*	1	No management feedback. Public education tool. Public presssure & perception on mgt.
	Static vs. dynamic.	*Static and dynamic reporting within SIS.*	0	Snap shot approach - 5 year process
	Context sensitive.	*Does the SIS take specific fisery context isues into account?*	1	Maintains broad national focus.
	External Influences.	*Informmation on overcapacity, subsidies, trade, fleet structure, IUU fishing and external influences.*	1	Minimal recognition of external factors in core reports (eg. IUU) but no indicators.

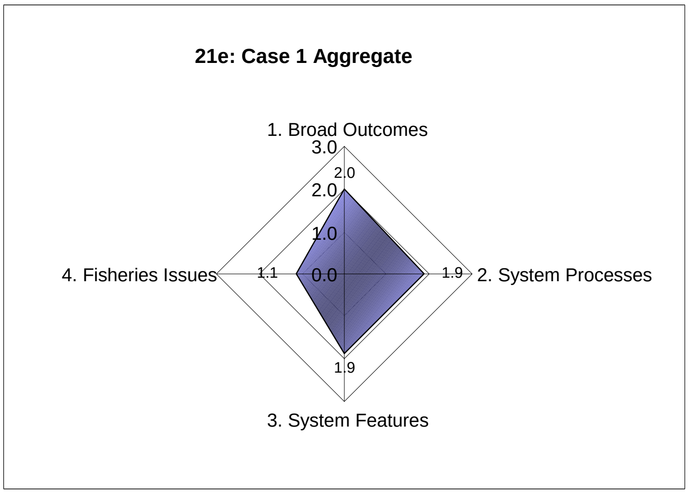
Figure 21 (a-e): Orientation graphs for Case Study 1.











4.6 Case 2. Environment Protection and Biodiversity Conservation Act 1999 Strategic Assessments.

4.6.1 Background

The development of the Oceans Policy and reforms to Commonwealth environmental legislation were a driving force behind sustainability indicators for Australian fisheries. The Oceans Policy contains two key commitments for indicators (Commonwealth of Australia 1998b):

- *To establish performance and operational sustainability indicators to take account of broader ecologically sustainable development objectives and make them a part of harvest, strategic and management plans.*
- *To continue to implement monitoring programs to ensure that fisheries management arrangements achieve long term sustainability.*[109]

This policy commitment has been underpinned by legislative developments in the environmental sector. With ongoing community concerns about the sustainability of stocks, the EPBC Act in 1999 introduced a process of fisheries assessments under a set of guidelines established by the Commonwealth environment agency, Environment Australia. The assessments cover Commonwealth managed fisheries and all export based fisheries (Commonwealth of Australia 2002b).

The strategic assessment of Commonwealth fisheries occurs under Part 10, Section 146 of the EPBC Act (Commonwealth of Australia 2002a). An assessment will cover the impacts of actions taken under a management plan for a fishery (or fisheries if the species is caught in more than one fishery). Strategic assessment involves assessing all activity under a plan (a cumulative approach) rather than assessing each individual action or permit (Commonwealth of Australia 2002b). The outcomes of the assessment must be included in the management plan or arrangements for each fishery. Once the fishery has been assessed, and the Environment Minister is satisfied with the arrangements, the management plan is endorsed and further environmental approvals under the act are not required (Commonwealth of Australia 2002; Australia. 2002). Two thirds of all Commonwealth fisheries must be assessed by 1 December 2003 and completed by 2005 (Commonwealth of Australia 2002b).

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[109] Australia's Ocean Policy, note 18 and 48 (Commonwealth of Australia 1998a).

The EPBC Act has developed a requirement under part 13A of the Wildlife Trade Provisions[110] that all fisheries based on export of marine species undergo an assessment to determine the extent to that management arrangements will ensure sustainable outcomes (Commonwealth of Australia 2002a). Before export approval is granted, each fishery will be required to be assessed under the guidelines. With the Commonwealth having power over import and exports, this allows fisheries under traditional State and Territory jurisdictions to come under the Commonwealth spotlight for assessment. Export component assessments must be completed by December 2003 (Commonwealth of Australia 2002b). For the strategic and export assessments, Environment Australia has developed a common set of guidelines, principles and criteria[111]. These guidelines, a set of benchmarks and terms of reference were completed in 2001 and are expanded below.

4.6.2 Structure and Indicators

The strategic and export assessments employ a framework structured around a set of guidelines[112] and a series of principles that state the 'vision' of a sustainable fishery. Each assessment of a fishery management arrangement must meet the set of principles to be considered 'sustainable' and gain the management accreditation and/or export permit. The *Guidelines for the Ecologically Sustainable Management of Fisheries* were developed by the Commonwealth Government in consultation with industry, State and Territory governments, and non-government groups (Commonwealth of Australia 2002b). The principles were initially based on the Marine Stewardship Council vision for a sustainable fishery (see Case Study 10).

The principles are broken down to a set of objectives and each objective has a series of information, assessment and management criteria (Commonwealth of Australia 2002b). This SIS is assessment orientated (as opposed to a reporting process) and employs a subjective analysis approach, common in environmental impact assessment style reporting. This framework is used for the rapid assessment of fisheries management plans for regulatory approval and permit

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[110] The Wildlife Trade Provision of the EPBC Act have replaced the former Wildlife Protection (Regulation of Exports and Imports) Act 1982.This Act regulated the export and import of Australian wildlife, including fisheries. To date most marine species caught and exported were exempted from regulation under the Act. With the Acts amendment and incorporation into the EPBC Act, this exemption was removed, requiring assessment before export permits are granted.
[111] The full guidelines are found at http//www.ea.gov.au/coasts/fisheries/assessments/index.html. A summary is below. Assessing export based and/or Commonwealth managed fisheries leaves an obvious gap for fisheries that are focused on domestic production under state jurisdiction. These fisheries however will be assessed by other State mechanisms or cooperative approaches such as the Standing Committee program (Case Study 3 below).
[112] See Comm of Australia (2002) for a full description of the guidelines and accreditation benchmarks.

processes. Once the assessment is complete, the Minister for Environment and Heritage may accredit the Management Plan and make a declaration under the EPBC Act that actions under the accredited plan or policy do not require further impact assessment approval (AFMA 2002; Commonwealth of Australia 2002). When deciding to accredit a management plan, the Minister must be satisfied that it meets the guidelines, principles and criteria. The minister may establish several terms and conditions on the fishery management plan to meet final accreditation. The Minister may also review these conditions and the accreditation. It is important to note that this represents a significant shift in Australian fisheries policy as the Minister for the Environment has established regulatory powers to alter and set conditions for fisheries management plans on the basis of sustainability principles (Ward et al 2002). The export conditions also allow for increased Commonwealth regulation of State managed and export orientated (high value) fisheries.

Fluidity and subjectivity is deemed necessary for rapid assessment of management plans driven by the legislative timetable. The system does not set actual indicators (that is, specific units of measurement). The feature of this system is that it is a flexible assessment process – the management agency states how each criterion is being met with further analysis provided by the assessment body - the Sustainable Fishery Section of Environment Australia. The decision whether the criterion has been met is a subjective one and not based on a quantitative score. This flexibility is deemed necessary to engage a diversity of stakeholders and facilitate rapid assessments in a limited timeframe. This approach is based on the philosophy of a gradual, incremental improvement of fisheries management by an external environmental authority. The aim is not to assess quantitative indicators but to engage management in an evolving dialogue aimed at incorporating environmental concerns into fisheries to the satisfaction of the Environment Minister. The principles, objectives and criteria that form the basis of the SIS are outlined in Table 10 below.

Table 10. Principles, objectives, and criteria of the Guidelines for the Ecologically Sustainable Management of Fisheries (Commonwealth of Australia 2002b)

<u>Principle 1.</u> A fishery must be conducted in a manner that does not lead to over-fishing, or for those stocks that 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.

Information requirements

- There is a reliable information collection system in place appropriate to the scale of the fishery. The level of data collection should be based upon an appropriate mix of fishery independent and dependent research and monitoring.

Assessment

- There is a robust assessment of the dynamics and status of the species/fishery and periodic review of the process and the data collected. Assessment should include a process to identify any reduction in biological diversity and/or reproductive capacity.
- The distribution and spatial structure of the stock(s) has been established and factored into management responses.
- There are reliable estimates of all removals, including commercial (landings and discards), recreational and indigenous, from the fished stock. These estimates have been factored into stock assessments and target species catch levels.
- There is a sound estimate of the potential productivity of the fished stock/s and the proportion that could be harvested.

Management responses

- There are reference points (target and/ or limit) that trigger management actions including a biological bottom line and/or a catch or effort upper limit beyond which the stock should not be taken.
- There are management strategies in place capable of controlling the level of take.
- Fishing is conducted in a manner that does not threaten stocks of by-product species (1.1.1 to 1.1.7 should also apply to by-product species).
- The management response, considering uncertainties in the assessment and precautionary management actions, has a high chance of achieving the objective.

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 time frames.

Management responses

- A precautionary recovery strategy is in place specifying management actions, or staged management responses, which are linked to reference points. The recovery strategy should apply until the stock recovers, and should aim for recovery within a specific time period appropriate to the biology of the stock.
- If the stock is estimated as being at or below the biological and/or effort bottom line, the management responses such as zero targeted catch, temporary closure, or ‘whole of fishery’ effort or quota reduction are implemented.

<u>Principle 2.</u> Fishing operations should be managed to minimise their 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.

Information requirements

- Reliable information, appropriate to the scale of the fishery, is collected on the composition and abundance of bycatch.

Assessments

- There is a risk analysis of the bycatch with respect to its vulnerability to fishing.

Management responses

- Measures are in place to avoid capture and mortality of bycatch unless it is determined that the level of catch is sustainable (except endangered or protected.)
- An indicator group of bycatch species is monitored;
- There are decision rules that trigger additional management measures when there are significant perturbations in the indicator species numbers.

Table 10 continued. Principles, objectives, and criteria of the Guidelines for the Ecologically Sustainable Management of Fisheries (Commonwealth of Australia 2002b))

- The management response, considering uncertainties in the assessment and precautionary management actions, has a high chance of achieving the objective.

Objective 2. The fishery is conducted in a manner that avoids mortality of, or an injury to, endangered, threatened or protected species and avoids or minimises impacts on threatened ecological communities.

Information requirements
- Reliable information is collected on the interaction with endangered, threatened or protected species and threatened ecological communities.

Assessments
- There is an assessment of the impact of the fishery on endangered, threatened or protected species.
- There is an assessment of the impact of the fishery on threatened ecological communities.

Management Responses
- There are measures in place to avoid capture and / or mortality of endangered, threatened, or protected species.
- There are measures in place to avoid impact on threatened ecological communities.
- The management response, considering uncertainties in the assessment and precautionary management actions has a high chance of meeting the objective.

Objective 3. The fishery is conducted, in a manner that minimises the impact of fishing operations on the ecosystem generally.

Information requirements.
- Information for analysis in 2.3.2 is collated and / or collected covering ecosystem impacts from the fishery.

Assessment
- Information collected and risk analysis, appropriate to the scale of the fishery and its potential impacts, is conducted on the following components: *Impacts on ecological communities; Impacts on food chains; Physical environment.*

Management responses
- Management actions are in place to ensure significant damage to ecosystems does not arise impacts.
- Decision rules trigger further responses when monitoring detects impacts on selected ecosystem indicators beyond a predetermined level or application of precautionary approach.
- The management response, considering uncertainties in the assessment and precautionary management actions has a high chance of meeting the objective.

4.6.3 Status

With a legislative timetable enabling most assessments within 2 years this indicator system has seen the rapid assessment of several fisheries (AFMA 2002, 2002b, 2003a, 2003b, 2003c). Assessments that are completed and in progress at the time of writing are summarised below.

Table 11. Status of assessments under the Guidelines for Ecologically Sustainable Fisheries

Fishery	State / Commonwealth	Development
Tasmanian Marine Aquaria Species Fishery	State	Completed & Approved
Queensland Marine Aquarium Fish Fishery	State	Completed & Approved
Victorian Rock lobster	State	Draft assessment
Victorian Giant Crab Fishery	State	Completed & Approved
Western Australian Commercial Shell Fishery	State	Completed & Approved
Tasmanian Abalone Fishery	State	Completed & Approved
Queensland Spanner Crab Fishery	State	Completed & Approved
Tasmanian Abalone Fishery	State	Completed & Approved
Tasmanian Rock Lobster Fishery	State	Completed & Approved
Tasmanian Abalone Fishery	State	Completed & Approved
South Australian Abalone fishery	State	Draft Assessment
Shark Bay Scallop Fishery	State	Draft assessment
NSW Estuary General Fishery	State	Completed and Approved
NSW Estuary Prawn Trawl	State	Completed and Approved
NSW Ocean Hauling	State	Completed and Approved
Northern Territory Spanish Mackerel Fishery	State	Draft assessment
Northern Territory Mud Crab Fishery	State	Completed & Approved
Northern Territory Timor Reef Fishery	State	Completed & Approved
Exmouth Gulf Prawn Fishery	State	Draft assessment
Shark Bay Prawn	State	Draft assessment
Shark Bay Scallop Fishery	State	Draft assessment
Western Rock Lobster Fishery	State	Draft assessment
Torres Strait Prawn Fishery	Commonwealth	Draft assessment
Torres Strait Tropical Rock lobster fishery	Commonwealth	Draft Assessment
Small pelagic fishery	Commonwealth	Draft Assessment
Skipjack Tuna fishery	Commonwealth	Draft Assessment
Bass Strait Scallop Central Zone Fishery	Commonwealth	Completed & Approved
Heard Island and McDonald Islands Fishery	Commonwealth	Completed & Approved
Marine Aquarium fisheries	Commonwealth	Completed & Approved
Bass Strait Scallop Central Zone Fishery	Commonwealth	Draft assessment
Southern Blue-fin Tuna Fishery	Commonwealth	Draft assessment
Southern and Eastern Scalefish and Shark	Commonwealth	Draft assessment
Eastern Tuna and Billfish Fishery	Commonwealth	Completed & Approved
Southern and Western Tuna and Billfish Fishery	Commonwealth	Draft assessment
Coral Sea Fishery	Commonwealth	Draft Assessment
Northern Prawn Fishery	Commonwealth	Completed & Approved
Torres Strait Tropical Rock Lobster Fishery	Commonwealth	Draft Assessment
Southern and Eastern Scalefish and Shark	Commonwealth	Completed & Approved

Adapted from (Commonwealth of Australia 2002; Sustainable Fisheries Section 2002)

4.6.4 Scoring against the assessment framework

The EPBC assessments are scored against the conceptual framework in Table 12 below and summarised in Figure 22 (a-e).

In terms of strategic outcomes, the SIS in Figure 22(a) obtains an above average score (2) for understanding the focus fishery system and nesting within a broader societal notion of sustainability. The SIS considers fisheries issues including target species, ecosystem and management considerations. In terms of contributing to a broader notion of sustainability the SIS nests within a broader Oceans Policy context and the legislative framework of the EPBC. Further developments in the Oceans Policy / EPBC process should contribute to the outputs of the SIS being interpreted in a wider policy context.

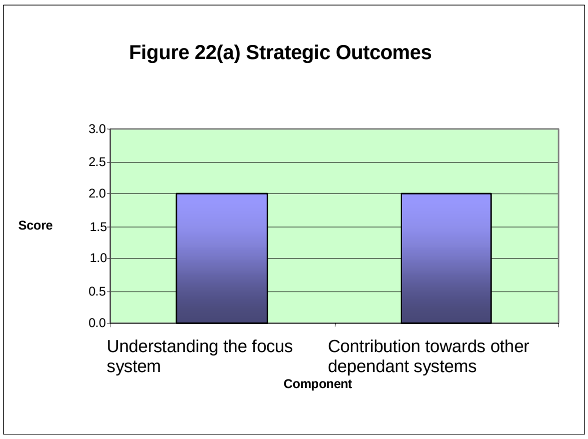
Figure 22(b) displays an overall strong System Process score highlighting effective structures that ensure efficiency in assessing sustainability and incorporating the results into decision-making**.** The orientation chart displays a trend towards input processes with a score of 2.7. The SIS displays significant policy relevance that drives the structure of the system and defines the outputs. A strong core and sub-structure sets the definition, framework, objectives and criteria for assessing fisheries sustainability. This score would be improved by increased use of quantified measures rather than the subjective method employed by the SIS. Output processes include issues of aggregation, visualisation and decision influence. The SIS scores low in aggregation ad visualisation, but high in decision influence leading to an overall average score. This stems from the fact that the SIS feeds directly into improvement of fisheries management plans on the basis of its assessment.

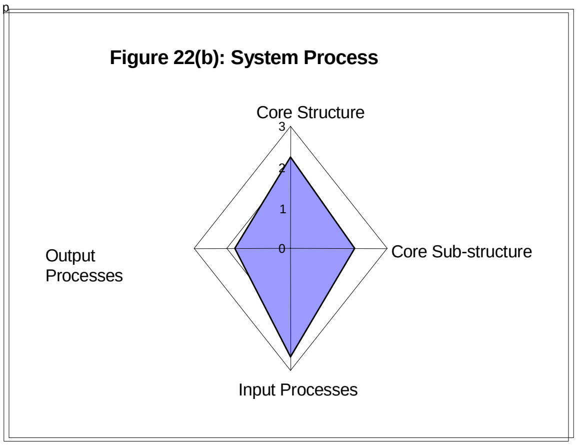
Considering the significant attributes and features of sustainability research in Figure 22(c), the SIS scores well in the Project Management component (3) and above average in Participation (2) and Integrative Capacity (2). The SIS generally has the ability to maintain itself in terms of institutional capacity, organisation, finance, and marketing. The SIS is generally lacking in Adaptive Management approaches with a score of 1.7. Improvements to social and institutional indicator development and a formal monitoring program would increase this score.

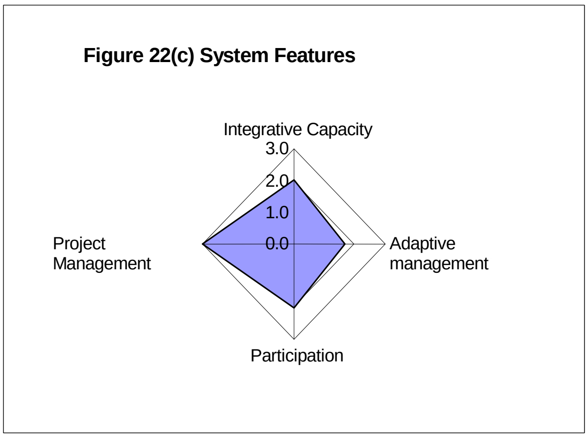
Table 12 Case 2 Scoring

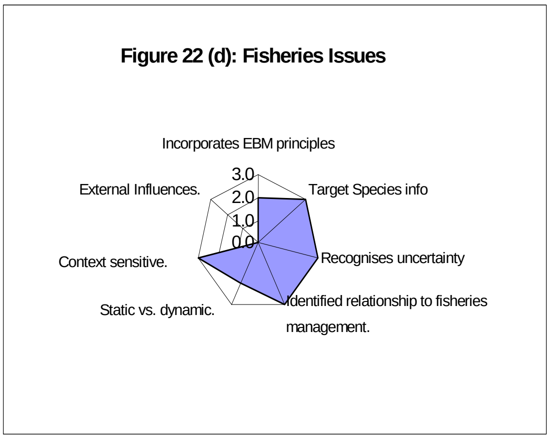
Case Study 2: EA Guidelines for the Ecologically Sustainable Management of Fisheries.				
Strategic Objective	***Sub Objective***	***Operational Objective***	***Score***	***Notes***
1. Strategic				
	Understanding the focus system	*System state and viability*	2	SIS contributes to understanding assessed fisheries in Commonwealth & State jurisdictions.
	Contribution towards other dependant systems	*System contribution to broader societal sustainability.*	2	SIS linked to EPBC Act aim in assessing sustainability of fisheries. Links to Oceans Policy goals.
2. System Processes				
	Core Structure	*Interpretation and definition of sustainability.*	3	clear definition and principles established. Act as guide for setting objectives and criteria.
		Framework classification.	2	Organising framework based on themes of target, ecosystem and management principles. Table 10
		Dimensions of sustainability.	1	Focus on ecological, environmental and management dimensions. Table 10.
		Criteria and sub-criteria.	3	Dimensions subdivided into relevant measurable components. Table 10.
	Core Sub-structure	*Objectives*	3	Specific broad objectives set. Provide direction for subjective measurement and analysis.
		Indicators: Scientific	2	No qualitative indicators set, subjective reporitng but on a scientific basis. Criteria represent proxy inddicators.
		Indicators: Functional	3	Relevant reporting mechanism. Subjective reporting aginst criteria. Flexible approach for assessments.
		Performance values	0	No performance values established. SIS does not report over time. No benchmarks.
	Input processes	*Policy context*	3	SIS within Guidelines for Sustaiable Mgt of Fisheries. EPBC Legislative basis to assessments that brings stakeholders to table.
		Indicator feedback	3	Criteria tested using a series of case studies. Legislation states review after 3 years.
		Stakeholder / user feedback	2	Feedback obtained in road testing and ongoing application of SIS to fisheries - Agencies reports.
	Output Processes	*Visualisation & presentation.*	1	Minimal use of visualisation techniques in assesment reports. Text based, cluttered. See references for AFMA (2002, 2003b)
		Communication & reporting	3	Basic reporting of results against the guidelines. Available over www.ea.gov.au
		Aggregation and scorecards	0	No methods of aggregation - discussed or applied.
		Decision making influence	3	Highly relevant process for decision making, directly influences management plans and licencing.
3. System Features				
	Integrative Capacity	*Interaction of sustainability dimensions.*	1	Primarily an evironmental and management focus. Target sp., ecosystem effects, and management actions.
		Integration with other reporting systems and sectors	3	Reports on all fisheries at Commonwelath & state levels (Table 11). Integrates with mgt planning at Comm / State level
	Adaptive management	*Social indicator development.*	1	Minimal use of social and economic indicators in core policy document. Adapted from MSC ecosystem criteria.
		Institutional indicator develop.	2	Basic management and institutional indicators, focus on fisheries management plan (Objective 3 in core document)
		System monitoring & feedback	2	Basic monitoring from reports feeds back via www. Regular newsleter of status.
	Participation	*Participation of stakeholders*	1	Primarily a top down approach driven by government. Examples of industry dissatification with process & lack consultation.
		Participation of decision makers and relevant institutions.	3	Strong linkages within commonwealth departments - from legislation & Oceans Policy.
	Project Management	*Institutional Capacity*	3	Sufficient capacity and skills through Environment Australia and Sustainable Fisheries Section.From WWW site.
		Marketing and R&D	3	Extensive marketing through industry and stakeholder media. Including industry newsletters, ngo publications, conferences.
4. Fisheries Issues				
	Incorporates Ecosystem Mgt Principles	*SIS reflect broader ecosystem based management principles.*	2	Presence of ecosystem mgt principles in core objectives. High level objectives in formal policy.
	Target Species info	*Indicators assess state of the target stock , used in management plans.*	3	Development of target species assessments - in stock assessment reports.
	Recognises uncertainty	*Assessments explicitly recognise all forms of uncertainty.*	3	A clear regconition of uncertainty - reports have driven precautionary approaches in select fisheries.
	Identified relationship to fisheries management.	*Indicators feedback to mgt.*	3	SIS feeds into fisheries mgt plans. Management Plans for major fisheries required to implement recommendations from SIS.
	Static vs. dynamic.	*Static and dynamic reporting within SIS.*	2	Dynamic approach requiring regular feedback and assessmet of target stock productivity. Adjustment of mgt plans.
	Context sensitive.	*Does the SIS take specific fishery context isues into account?*	3	SIS is context relevant, takes direct issues into account in criteria and assessments. Assessments at fisheriy level.Table 11
	External Influences.	*Information on overcapacity, subsidies, trade, fleet structure, IUU fishing and external influences.*	0	No recognition of external influences in assessment reports or core criteria.

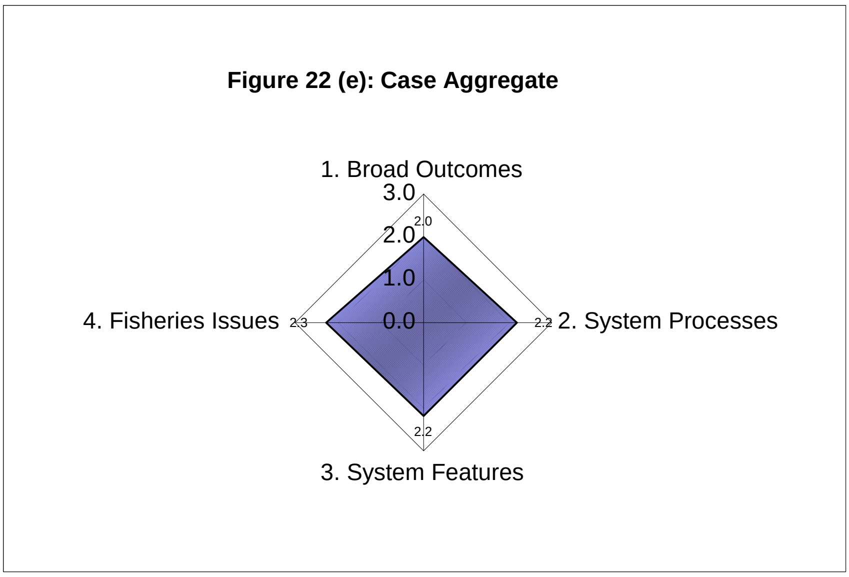
Figure 22 (a-e) Orientation graphs for Case 2











For Fisheries Issues Figure 22(d) displays a high score in target species, uncertainty, relationship to fisheries management and context sensitivity. These scores relate to the legislative commitment of the SIS - the strategic assessment of Commonwealth and export fisheries systems, which are predominantly target species based. In addition, the indicator system contributes to the development of ecosystem-based approaches in management by requiring the system to incorporate basic ecosystem concerns to pass the assessment (or develop binding conditions). Further improvements to the SIS from including external influences in fisheries and refinement of ecosystem based management indicators will improve the score in this sub-component.

The Case Aggregate displays an overall balanced SIS with an above average score in all four strategic criteria, with a tendency towards Fisheries Issues (2.2). Future developments of the SIS in the areas of performance measurement, visualisation and aggregation approaches, stakeholder participation, socio-economic and institutional indicators, and external fisheries issues will contribute towards an effective system that externally assesses fisheries sustainability on a routine basis and contributes findings towards improved fisheries management and decision making. The progression towards quantitative rather than qualitative reporting would be an advantage.

4.7 Case 3. National ESD Reporting Framework (NESDRF).

The National ESD Reporting Framework for Fisheries (NESDRF) is an initiative from Australian fisheries management agencies to develop a reporting system that meets community expectations, jurisdictional requirements, emerging market based certification programs and meets the standards of all stakeholders in the fisheries sector. The NESDRF was developed by the now replaced Standing Committee on Fisheries and Aquaculture which comprised of the representatives State and Commonwealth fisheries agencies.[113] The development of this project was in response to other indicator initiatives being developed through the Oceans Policy and Environment Australia, and reflects an attempt to develop a national framework to measure sustainability in all fisheries jurisdictions (Fletcher 2001; Fletcher et al 2002).

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[113] Following the reforms to all Ministerial Councils, the responsibilities of the SCFA are undertaken by the Marine and Coastal Committee of the Natural Resources Management Council.

4.7.1 Background

In 1999 the Standing Committee on Fisheries and Aquaculture (SCFA) agreed to establish Sustainability Indicators Working Group and promote the development of nationally agreed criteria and indicators. The Fisheries Research and Development Corporation further funded a study to develop a framework for agencies to provide accounts of the current performance of their fisheries. Using a consultative approach a draft ESD Reporting Framework was developed (SCFA_FRDC Project 2000; Fletcher et al 2002). This framework was tested through a series of case studies with the intent to customise it to a diverse set of different fisheries, gears types and jurisdictions [114] (Fletcher et al 2001). A significant milestone in the project occurred when the Standing Committee for Fisheries and Aquaculture working group met in June 2000 with a reference group of major stakeholders and agreed on a set of sustainability definitions and objectives (SCFA_FRDC Project 2000).

The NESDRF presents a multiple number of outputs. The reports provide a compilation of information or fishery 'resume' detailing the management arrangements and environmental, socio-economic and governance considerations (Chesson 2000). This is useful for strategic planning purposes (such as Oceans Policy regional planning) and public accountability exercises (Fletcher et al 2002). Development of the reports aimed to provide a greater transparency of performance by industry, the management agency and the wider community (Fletcher et al 2002). Reports will become part of processes for auditing or certification by a relevant third party agency including applications to Environment Australia for strategic assessments and export licensing. It is envisaged that reports could also be used for eco-certification programs such as the Marine Stewardship Council (Fletcher et al 2002).

4.7.2 Structure and Indicators

The NESDRF identified the need for the use of indicators within a logical structured framework (as opposed to the subjective method used by Case 2). Indicators by themselves were recognised to be of limited value unless they are meaningful, scale dependent and nested within a set of objectives and performance measures (Fletcher et al 2002; Sainsbury 2003). Effective performance evaluation requires a statement of what is acceptable in terms of indicator variation. Objectives, indicators and performance measures form a structured reporting set. The NESDRF

[114] The case studies included recreational and aquaculture based studies. See (FRDC 2002).

has established a framework along with a process to systematically identify issues and risk, develop objectives and identify the indicators that need to be measured (Fletcher et al 2001).

The SIS employs an ESD based, hierarchical subdivision approach. At the top of the framework lies the core definition of sustainability, the definition that is promoted by the National Strategy for ESD (Commonwealth of Australia 1992). It states that Ecologically Sustainable Development is:

> *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.*

This definition was divided into three broad dimensions consisting of 8 criteria that represent sustainability issues within the fishery. They consist of:

Contributions of the fishery to ecological well-being

1. Retained species
2. Non-retained species
3. General Ecosystem

Contributions of the fishery to human well-being.

4. Indigenous well-being.
5. Community and regional well-being.
6. National social and economic well-being.

Factors affecting the ability of the fishery to contribute to ESD

7. Impact of the environment on the fishery
8. Governance Arrangements

Each criterion represents an important issue for fisheries sustainable development. To identify more specific objectives, indicators and performance measures each criteria undergoes 'deconstruction' into more specific sub-criteria. The chosen method is an approach developed by the Bureau of Rural Sciences, called the component tree approach (Chesson 1999; Whitworth et al 2000). The tree breaks down each criterion in an objective and transparent fashion, often under the direction of a set of stakeholders. This design is flexible and has already been used against commercial fisheries (Chesson 1998; Chesson 1999; Chesson 2000; and Whitworth et al

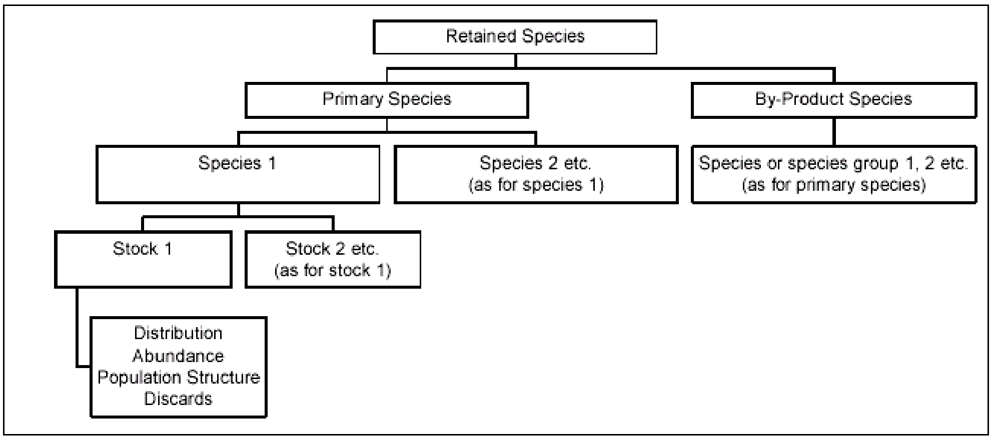
2000). Each tree is customised to a particular fishery and issues are added and dropped as necessary. (Fletcher et al 2002) states that component trees are useful approach because they:

- Provide a mechanism for the assessment of fisheries to be completed in a consistent manner.
- Help identify and clarify issues.
- The tree structure helps focus attention and deal with the different types of issues in a structured manner.
- Provide a useful communication and education tool.

Each of the generic set of trees is displayed below. Each tree is customised to a fishery and provides the overall template that guides the sustainability report. There is one *generic component tree* for each of the eight components (FRDC 2002). They are used as a starting point, with each fishery tailoring them to suit their individual circumstances, expanding some sub-components and collapsing or removing others, depending upon the fishing method, areas of operations and the species involved in the fishery. The NESDRF does not set specific indicators; this is left up to each fishery on the basis of the subdivision. Each tree is identified below.

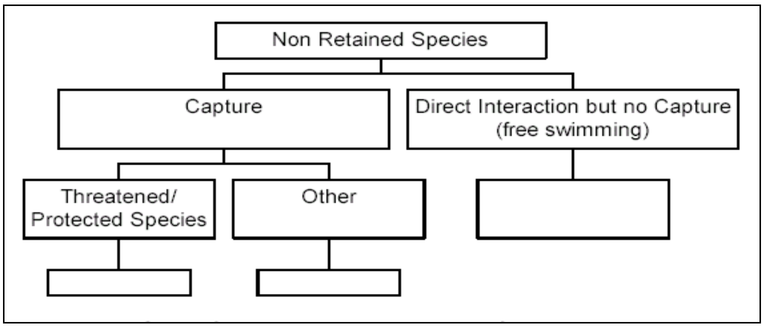
With many potential indicators, the NESDRF has a risk assessment methodology that can be used as a tool to prioritise the identified issues under each tree. This operates by an assessment of the risk associated with each of the identified issues as an initial screening exercise. It works by assigning a level of consequence and the likelihood of this consequence occurring for each issue. From the combination of consequence and likelihood, an overall level of risk is generated that is used to decide whether a component tree issue requires the development of indicators.

Figure 23 Retained species tree.



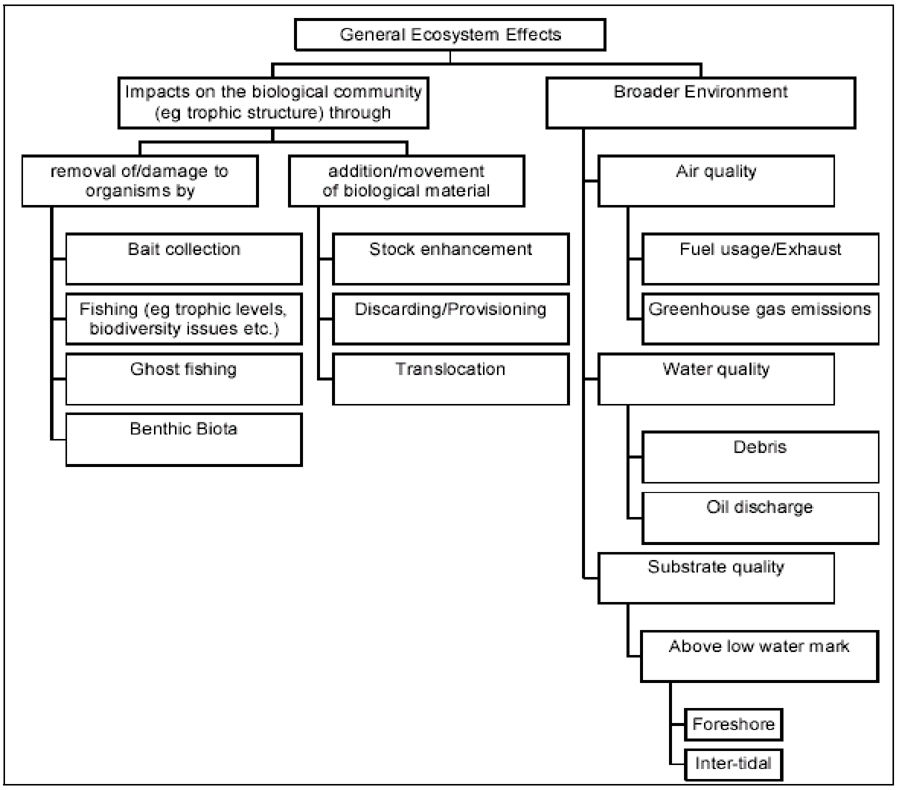
The retained species tree (Figure 23) deals with the species that are caught by the fisherman, including the primary (the target species) and the by-product species. The by-product species can be caught in other fisheries or caught primarily in the focus fishery. The by-product species are still marketed by the fishers. This approach is based on the notion that by-catch is a variable term that can mean different things and include retained and non-retained species. Hence all the retained species are dealt with in this component tree. Objective relate to the sustainable harvesting of stocks.

Figure 24 Non-retained species tree.



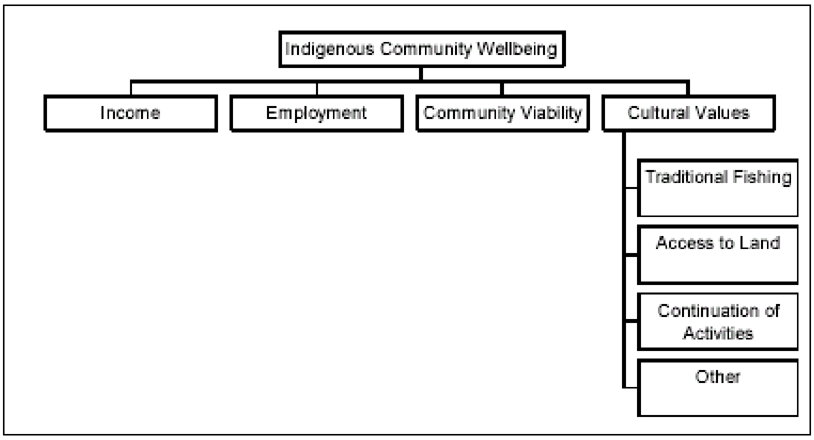
The non-retained species tree (Figure 24) refers to those species that no one in the fishery wishes to catch and market at any time, irrespective of their size or life history (Fletcher et al 2002). This is the ‘other half’ of the bycatch issue discussed above, and allows for the management of the impacts upon all elements of a stock in one location (Fletcher et al 2002). As a result, the objectives the non-retained species component relate to minimisation of capture. Non-retained species is split into capture and direct interaction criteria. Capture refers to species captured in operations and discarded and is split into threatened and others. Direct interaction allows for interaction with species not landed: for example dugongs or seabirds.

Figure 25 General Ecosystem tree



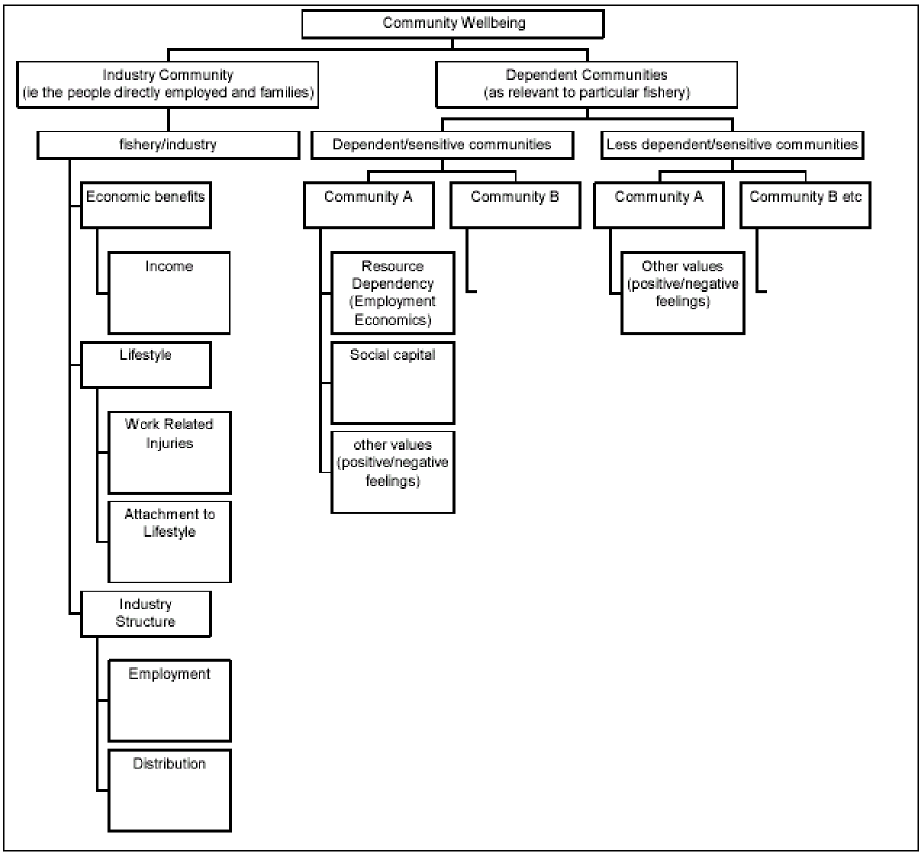
The general ecosystem effects tree (Figure 25) reflects the recent shift to ecosystem-based management concerns and identifies criteria that cover the diffuse interactions of the fishery with the trophic structure, the marine ecosystem and the broader physical environment. The component tree breaks down the issue into i) impacts from the damage or removal caused by the fishery; ii) impact from additions and enhancement; and iii) impacts on air and water quality (Fletcher et al 2002). The ecosystem effects component tree identifies the emerging issues that need to be addressed by management agencies. The setting of specific measures and indicators is more uncertain with a higher chance of error. The component tree approach is useful for identifying these issues and identifying priorities for research.

Figure 26 Indigenous well-being trees



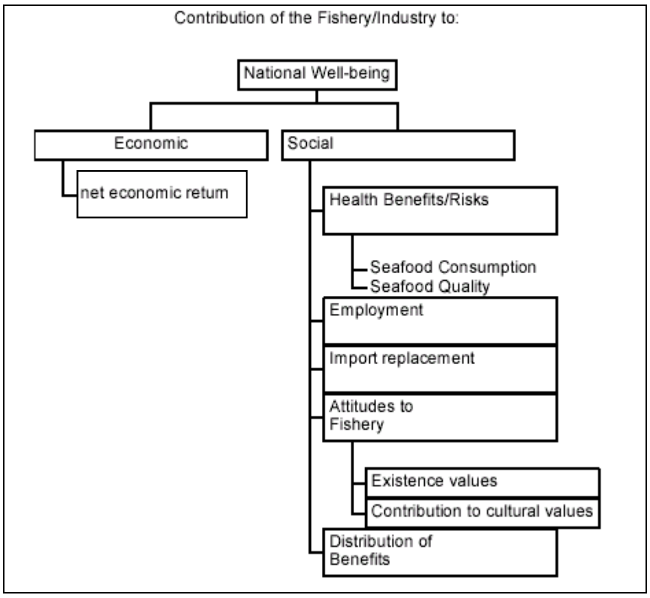
The indigenous well-being tree (Figure 26) is the focus point for investigating the positive and negative contribution of the fishery to indigenous communities and values. This component tree is an initial attempt to identify relevant criteria for setting indicators, and will require innovative methods of issue identification, data collection and decision use.

Figure 27 Community Well-being tree.



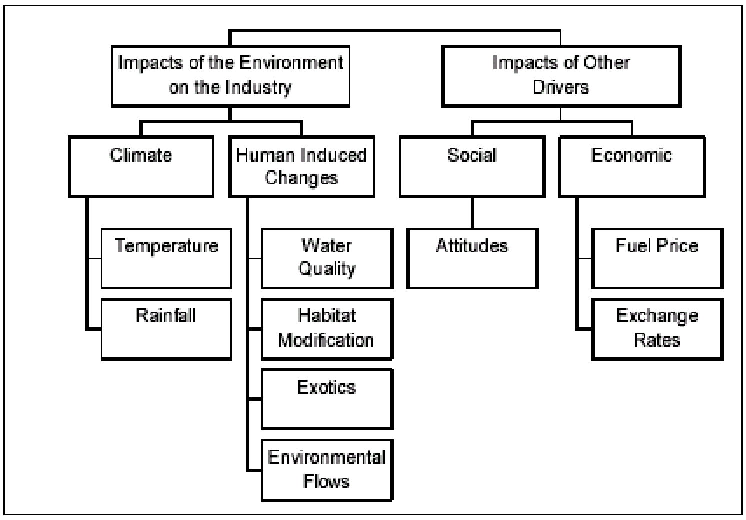
The community well being tree (Figure 27) reflects the potential effects of the fishery upon local and regional communities that are associated with the fishery (Fletcher et al 2002). The issue is divided to reflect the effect on the industry based community and fisheries sector and the effects upon the broader dependent communities and lesser dependent communities. The tree covers economic, lifestyle and workforce considerations within the industry sector. On the dependent community side, the criteria reflect the dependence of the broader community on the fishery and social capital concerns. The investigation of social capital, a relatively new approach in assessing the health of communities, is a realisation of the increased importance of social factors in fisheries management for sustainability. It refers to 'the norms and networks that enable collective action' (Fletcher et al 2002) and relates to healthy communities. Indicators of social capital are being debated, refined, and tested in this indicator system.

Figure 28 National social and economic well-being tree



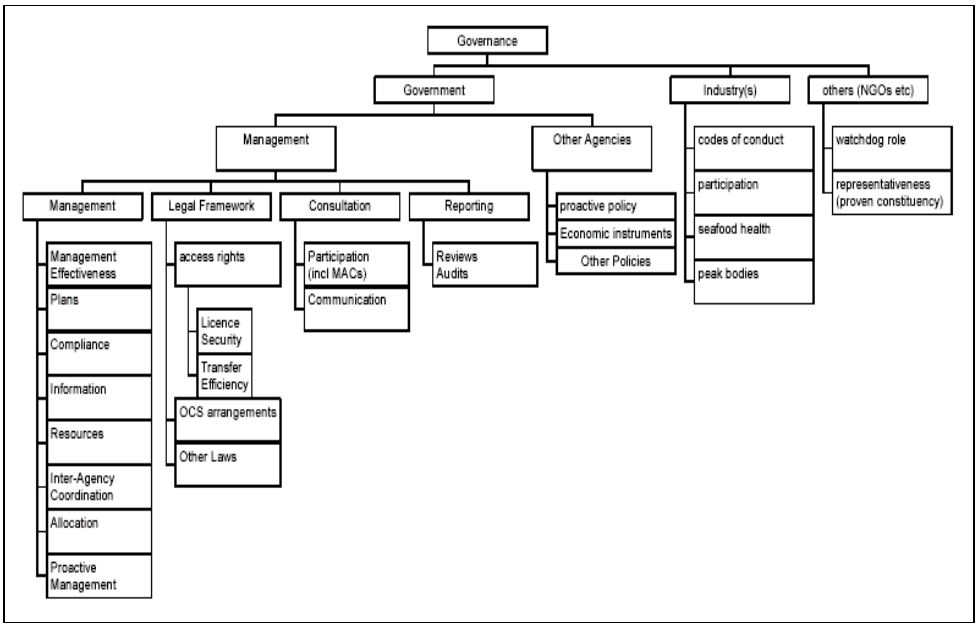
National and social economic well-being tree (Figure 28) represents the costs and benefits from the fishery at a broader scale. While the economic criteria relates to national economic returns, the social criteria reflect a range of health issues, employment generation, community attitudes and equity. This range of issues is acknowledged as important as the concern of the community over the state of the fishery can influence policy, decision-making and resource access (Fletcher et al 2002).

Figure 29 Impact of the environment on the fishery



This tree reflects broader physical environmental parameters that can affect the performance of the fishery. These effects are not controlled directly by the management agency, but still must be accounted for in decision-making. The criteria are split between environmental effects from climate and water quality (the physical parameters) and the indirect impacts of socio-economic forces, particularly at the macro-level, such has exchange rates and the price of fuel.

Figure 30. Governance tree.



The final tree to identifies criteria for all aspects of government, industry and non-government decision-making (Figure 30). This includes all legislative, administrative and bureaucratic processes that need to be completed to enable the issues to be dealt with effectively. The government part of the tree is split into criteria that relate to the management agency and include plans, compliance, legal aspects and rights and consultation. It also includes the impacts of other associated agencies (for example economic agencies). The tree identifies industry and NGO governance criteria including codes of conduct, participation and watchdog roles. Specific indicators to measure the above criteria are still in a stage of development and formulation. Setting the objectives, indicators and performance measures for governance criteria can be a sensitive process and one that is difficult to assess depending on the legislative arrangements for the fishery. However it is critical that governance issues are considered in the SIS – identifying all the aspects of influence, jurisdiction, and roles issues leads to informed decisions.

4.7.3 Status

After a period of national consultation and development, the SIS has conducted a series of test cases and prepared a report on an initial trial application. The approach has been open for use by fisheries agencies, yet in the light of other SIS demands from competing agencies such as Environment Australia; the momentum for developing the SIS has slowed considerably. However, the project still continues to gather some measure of support due to its broad appeal and industry basis, including the Western Australia Department of Fisheries using the system as the basis of annual sustainability reporting (Dept of Fisheries Western Australia 2002). The SIS is the core of an ongoing research project by the FRDC and has recently produced a 'How To' report that details the background, structure and application of the SIS to a candidate fishery (Dept of Fisheries Western Australia 2002).

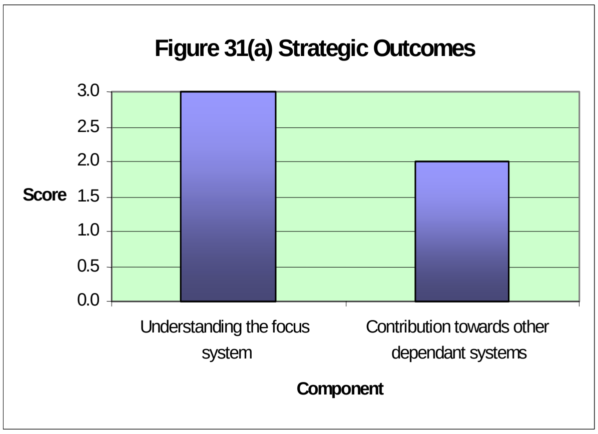
4.7.4 Scoring against the assessment framework

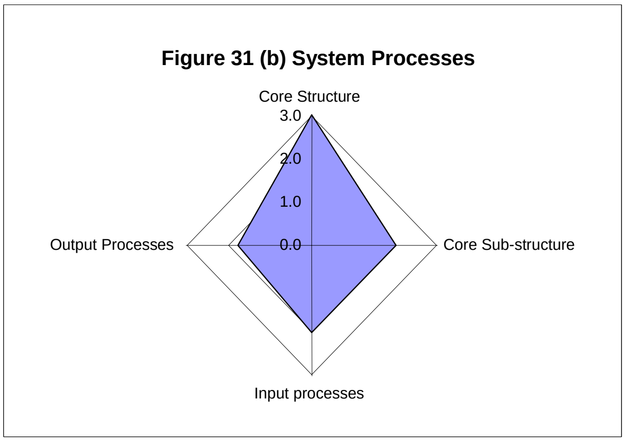
The SIS is scored below in Table 13 and Figure 31 (a-e). In Strategic Outcomes the SIS scores 3 in its ability to assess the viability of the focus system and an average result for its contribution to broader societal sustainability. The SIS employs a detailed examination of the different components of the fishery system and highlights these factors as the basis of a report. The system is expected to evolve into an assessment based SIS (Fletcher et al 2002). The use of component tress promotes the understanding of the system to decision makers and the public. The below score in dependent systems is expected to improve over time. The NESDRF specifically states that it is designed to assess a fisheries contribution to broader societal ESD, and facilitate the integration of short and long-term economic, social and environmental effects in all decision-making.

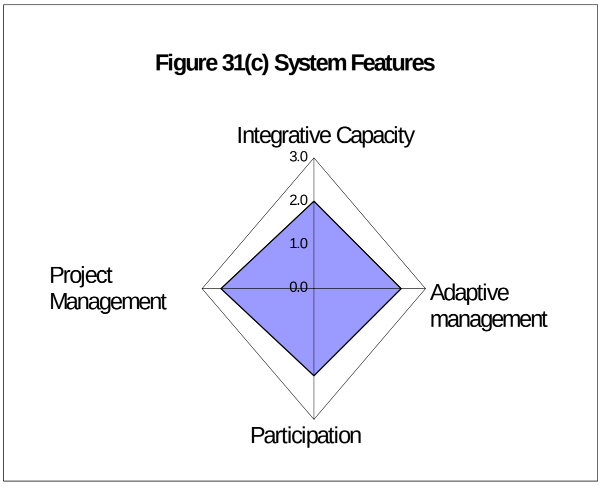
Table 13 Case 3 Scoring

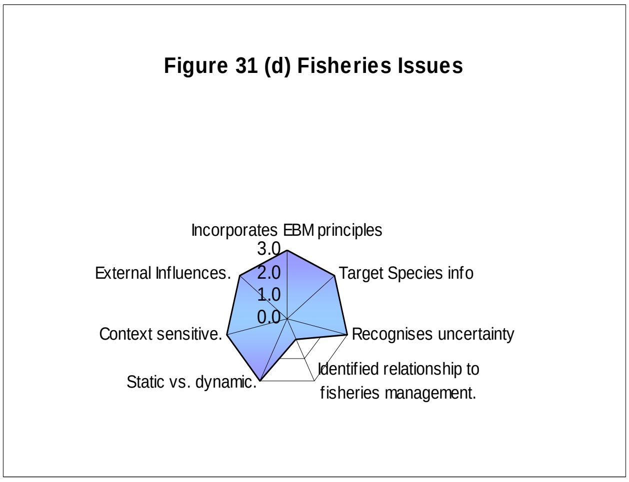
Case Study 3: NESDRM				
Strategic Objective	***Sub Objective***	***Operational Objective***	***Score***	***Notes***
1. Strategic				
	Understanding the focus system	*System state and viability*	3	Comprehensive approach to understanding fishery system dynamics across several dimensions Figs 23-30
	Contribution towards other dependant systems	*System contribution to broader societal sustainability.*	2	SIS developed to contribute to emerging sustainability demands in fisheries mgt (EPBC Act).
2. System Processes				
	Core Structure	*Interpretation and definition of sustainability.*	3	Focused vision and consensual definition. Sets the basis for the SIS. P159
		Framework classification.	3	Based on hierarchical subdivision approach, based on the ESD definition.
		Dimensions of sustainability.	3	Recognises the ecological, biological, economic, social and governacne dimensions. Figs 23-30
		Criteria and sub-criteria.	3	Use of component trees (generic criteria) that are applied to specific fisheries.
	Core Sub-structure	*Objectives*	2	objectives set for each criteria at the lowest level of component tree. Regognition of the role of objectives.
		Indicators: Scientific	2	Indicators proposed for each specific fishery. Expansion from target stocks and ecosystem measures.
		Indicators: Functional	2	Indicators at draft stage. Indicators rest within a defined policy framework and based on objectives.
		Performance values	2	PM are discussed and set for several proposed indicators. Further devleopment.
	Input processes	*Policy context*	2	Policy network exists for SIS application. No consensus on the utility of the SIS.
		Indicator feedback	2	Assessments at draft stage - feedback process not yet implementated. Positive feedback on framework.
		Stakeholder / user feedback	2	Regular feedback from stakeholders. Input into the design of model and through FRDC subprogam.
	Output Processes	*Visualisation & presentation.*	3	innovative visualisation. Component trees useful for determining issues & indicators. Figs 23-30
		Communication & reporting	3	Report template for each fishery based on component tree and core sub system.
		Aggregation and scorecards	0	No methods for aggregation.
		Decision making influence	1	Reporting only. SIS available on voluntary basis for use by Fisheries agencies / industry.
3. System Features				
	Integrative Capacity	*Interaction of sustainability dimensions.*	3	Broad focus and attempt to quantify a broad array of sustainability issues.
		Integration with other reporting systems and sectors.	1	Attempts at integration with EA assessments but not sucessful at this stage. See www.fisheries-esd.com
	Adaptive management	*Social indicator development.*	3	Progressive social indicator basis but indicators in draft phase. Indigenous, community and national criteria.
		Institutional indicator develop.	2	Componet tree for governance. Fig 30.
		System monitoring & feedback	2	Regular review from project team. Documented on website. Moving towards assessment tool.
	Participation	*Participation of stakeholders*	3	Full participation of stakeholders in the development of the SIS.
		Participation of decision makers and relevant institutions.	1	Minimal use by fisheries mgt authorities except in Western Australia where formal application has occurred.
	Project Management	*Institutional Capacity*	3	Resources and funding by FRDC for project.
		Marketing and R&D	2	Emerging recognition but has not resulted in widespread application.
4. Fisheries Issues				
	Incorporates EBM Principles	*SIS reflect broader ecosystem based management principles.*	3	EBM is a core component of the SIS. Reflected in the component tree Fig 23.
	Target Species info	*Indicators assess state of the target stock , used in management plans.*	3	Well devleoped target species indicators and component trees. Fig 22.
	Recognises precaution	*Assessments explicitly recognise all forms of uncertainty.*	3	Risk analysis process to determine issues and what indicators are assessed. Progressive approach.
	Identified relationship to fisheries management	*Indicators feedback to mgt.*	1	Used in WA decision making, other jurisdictions have tested draft SIS.
	Static vs. dynamic.	*Static and dynamic reporting within SIS.*	3	dynamic nature recognised throgh criteria that refelct stock dynamics, economic pressures etc .
	Context sensitive.	*Does the SIS take specific fisery context isues into account?*	3	SIS highly context specific - demonstrated by applications to fisheries to date.
	External Influences.	*Information on overcapacity, subsidies, trade, fleet structure, IUU fishing and external influences.*	3	Broader social, governance and economic factors are included in the SIS.

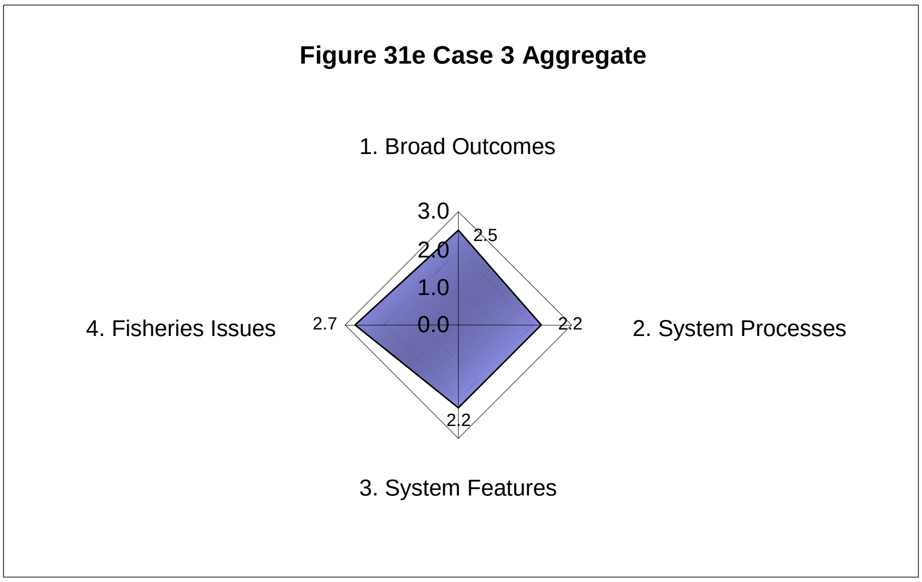
Figure 31 (a-e) Orientation graphs for Case 3.











The SIS therefore demonstrates the intent for an integrative approach with an above average score (2). However, the broader strategic contribution of the SIS is yet to be effectively realised in practice. Further development of links to broader policies and further use and recognition of the approach will increase this score.

Under System Processes, the SIS displays a strong core structure (score of 3) and above average sub-structure (2). The SIS is based on the Commonwealth of Australia's definition of ESD and a hierarchical component tree framework. It recognises the relevant dimensions and criteria of fisheries sustainability. The SIS clearly establishes the need for an efficient and robust sub-system of objectives, indicators and performance measures. In terms of input processes, (score of 2), further improvements are expected as the SIS matures and relates its findings to the broader policy context and incorporates feedback on the use of specific indicators. The SIS has an identified policy context; developed on the basis that sustainability has become an explicit requirement in most fisheries legislation in Australia, requiring the need for a reporting system. The SIS has been applied to fisheries in Western Australia but is yet to be formally applied outside this jurisdiction (Dept of Fisheries Western Australia 2002). The SIS obtains a below average score (1.8) for outputs, scoring high in reporting and visualisation but low in aggregation / scorecards and decision making influence. Further integration with Commonwealth reporting requirements and take up of the SIS by State authorities would improve this score, at the present time the SIS fulfils a descriptive and reporting capacity.

The SIS takes into account the attributes and policy directions of sustainability research and management with above average scores in all System Features components. Features of the SIS include a strong adaptive management approach with the development of social, economic and governance criteria and indicators. The SIS recognises the interaction of sustainability dimensions and the contribution of socio-economic factors. The SIS has been the basis of a Fisheries Research and Development Corporation project and is well resourced and marketed with emerging recognition as a useful tool for reporting on fisheries sustainability issues. Increased integration with other reporting systems and buy-in from decision makers will increase effectiveness.

The SIS maintains a strong performance in regard to Fisheries Issues with maximum score in majority of the components. The SIS incorporates ecosystem-based principles and indicators, assesses target stock status, includes precautionary approaches, adopts a dynamic approach to measurement, and is directly related to the fisheries context. To improve its relationship to management the SIS needs further development, recognition and uptake by the relevant agencies.

The Case Aggregate displays a well-balanced system with a trend towards Fisheries Issues (overall aggregate of 2.7). The SIS scores above average in all strategic components and demonstrates an effective system for reporting on sustainability concerns in fisheries. Improvements to specific operational components, mainly the integration of the SIS into decision-making regimes, will increase efficiency. The NESDRF remains one of the most advanced and innovative approaches to measuring and including sustainability in fisheries management, and the export of this approach will contribute significantly to the debate and application of indicators outside of this national context.

4.8 Conclusion

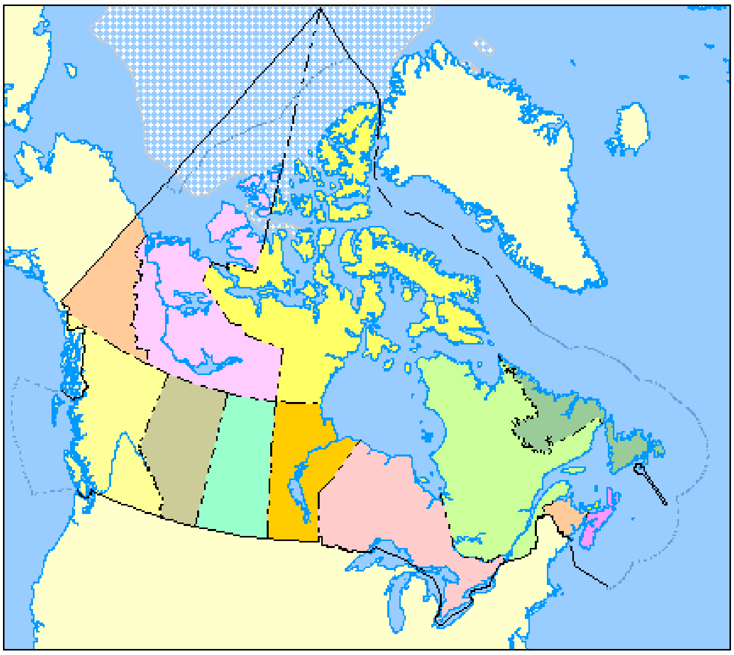
This case study examines in detail the range of initiatives that are being developed and implemented in the Australian national jurisdiction for reporting on fisheries sustainability. The initiatives range from broad community-based reporting approaches (Case 1: SoE), regulatory assessments based on ecosystem management and driven by a Commonwealth environmental authority (Case 2: EPBC), to agency based reporting that is ‘best-practice’ and addresses specific industry concerns and has general support (Case 3: NESDRF). Each approach is unique in terms of its reporting and assessment characteristics, jurisdiction and target audience, yet all systems collectively use similar criteria and indicators, report on ‘sustainable fisheries’ and focus on Commonwealth and State Fisheries. Two of the cases are based on Commonwealth legislative requirements (Case 1 and 2) while one is a voluntary approach (Case 3). There is a significant overlap between Case 2 and 3 in terms of addressing Commonwealth concerns for sustainable and well-managed fisheries, with Case 3: NESDRF emerging as a response to the regulatory approach driven by the Commonwealth environment department. However, Case 3 also fulfils a best practice approach that agencies can use for a variety of reporting requirements and enjoys considerable industry support. As these systems mature, mechanisms to avoid duplication of effort and unnecessary competition will be required.

Chapter 5: National Approaches Case Study: Canada

5.1 Introduction

Canada is the world's second-largest country, borders on three oceans, and is distinguished by its geographical, climatic, economic and social diversity (Earth Summit 2002; Canadian Secretariat, 2002). Canada's population is approximately 30.7 million with a third of it concentrated in four major cities: Toronto, Montreal, Vancouver and Ottawa (Canadian Secretariat, 2002). It ranks sixth in the world in gross domestic product per capita, based on its rich natural resource base - more than 80% of all exports go to the US (Auditor General 1997). Canada's EEZ occupies 12 million square kilometres (Ocean98 1998) (Figure 32).

Figure 32 Canadian Ocean Territory (Government of Government of Canada 2002b)



Canada is a constitutional monarchy and a federal state (DFO 1997a). Within the federal system, Canada has ten self-governing provinces, three territories and a number of self-governing Aboriginal communities (DFO 1997a). The Constitution divides powers between the federal and provincial governments with the federal government having jurisdiction over such matters as inter provincial and international trade, foreign affairs, communications, criminal law, fisheries, and Aboriginal affairs (DFO 1997a). Provincial government jurisdiction is over property and civil rights, local works and undertakings, municipal institutions and the development and management of natural resources (DFO 1997b).

Fisheries are an important industry for the Canadian domestic and international economy. They fulfil an important commercial, social, cultural and recreational role (Pinkerton and Weinstein1995). The major fishing grounds in Canada are on the Atlantic and Pacific coasts, however important inshore and freshwater fisheries exist between the west and east coasts (Pinkerton and Weinstein 1995). The fisheries sector employs 51,412 directly in the marine fishery, and 6,900 in the freshwater fishery (Haward et al 2002).

The value and quantity of Canada's fish and seafood exports in 1998 was US$ 2.2 billion and 497,468 tonnes respectively (Dobell and Charles 2002). In 1999, the export value of fishery products was US$2.62 billion. Fisheries on the Atlantic coast focus on pelagic fish, crustaceans and molluscs (Government of Canada 2001b). In 1997 the main species by volume were herring (184,433 t), shrimp (72,917 t), queen crab (71,369 t) and scallop (65,745 t). In terms of value shellfish fisheries dominated with lobster (US$ 286 million), followed by queen crab (US$ 146 million), shrimp (US$ 131 million) and scallop (US$ 72 million) (Government of Canada 2001b; Dobell and Charles 2002).On the Pacific coast in 1997 the main species landed were hake (97,300 t) followed by salmon (48,649 t), herring (31,539 t), and the multi-species rockfish fishery (18,400 t). In terms of value the top fisheries were salmon (US$ 79 million), herring (US$ 33 million), halibut (US$ 28 million), and ground fish (US$ 27 million) (Dobell and Charles 2002).

Canadian fisheries have experienced the economic and social problems that occur when important stocks are overfished. Perceived as a result of overfishing (Buckworth 1998), the early 1990s witnessed crashes in key stocks of Atlantic groundfish such as cod and haddock (Harris 1995). Following collapse of the resource and a subsequent moratorium imposed on commercial fishing for cod in 1992, industry restructuring and social dislocation in coastal communities across the Atlantic coast led to approximately 40,000 people out of work (Harris 1995). As a result of slow recovery of groundfish, industry has diversified its effort into rock lobster, crab and shrimp but doubt over the capacity of commercial fisheries to contribute to the local and national economies remains (Government of Canada 2001c). Salmon stocks on the Pacific coast are experiencing stock decline from fishing pressure, changing environmental conditions and influences from upstream terrestrial habitat alteration (Glavin 1998; Edwards 1999).

Fisheries management in Canada is undergoing a 'cultural shift' (Dobell and Charles 2002) with moves towards an integrated, precautionary, and ecosystem-based approach. Changes in norms and values have underpinned this development, and have been reflected in legislative developments such as Canada's Oceans Act. Fisheries policy and management reflect these trends and, like other marine resources, face challenges to operationalise sustainability into management.

5.2 The Policy Framework for Sustainable Development in Canada

Sustainable development issues are an area of overlapping responsibility between federal and provincial governments. Cooperation among the federal, provincial, territorial and Aboriginal governments is vital to the success of national policies (Government of Canada 2001c). Embracing a consultative approach, a number of coordinating councils have been created across policy fields such as environment, energy, forestry, and marine issues. However, the division of powers over environmental, social and economic decisions among the tiers of government adds significant complexity to achieving sustainable development goals (Government of Canada 2002a). Coordination within and between governments, the private sector and the public is required to reduce duplication, complexity and manage multiple interests (Government of Canada 2001b).

Key coordination and reporting mechanisms include the Federal Interdepartmental Committee, the National Round Table on Environment and the Economy, the Canadian Council of Ministers for the Environment, and the Commissioner of Environment and Sustainable Development (Government of Canada 2001c; Government of Canada 2002a). In addition sustainable development principles have been incorporated into legislation such as the *Canadian Environmental Assessment Act*, the *North American Free Trade Agreement Implementation Act*, *Canadian Environmental Protection Act 1999* and the *Environmental Assessment Act 1995 (*Government of Canada 2002a*).* As a result of emerging legislation (especially in the recent *Environmental Assessment Act* and *Environmental Protection Act)* Federal projects must take into account how a development contributes to sustainability and precaution (Government of Canada 2001a). In addition, provincial and territorial governments have, or are in the process of developing, sustainable development strategies to coordinate environment-economy issues (Government of Canada 2002a).

Public consultation is a legal requirement and governments have focused efforts to find means of involving multiple stakeholders in policy development. Forums and the 'roundtable' approach that bring together stakeholders have become important vehicles in these consultative processes (Government of Canada 2001c). The intent is to encourage debate and consensus building that crosses narrow interests. In 1986 the Federal and provincial governments developed the National Task Force on Environment and Economy, a group of 17 environment ministers, business leaders and environmental experts (Government of Canada 2001c; Government of Canada 2002a). The task force aimed to report on what actions were needed to move toward sustainable development. One of its key recommendations stated the need for collaborative leadership from all sectors of society. This pioneered the round table approach that brings sectors together to discuss problems and build consensus. The National Roundtable on Environment and Economy (NTREE) comprised of a chair and 24 appointees that represent business, labour, academia, interest groups and indigenous communities (Government of Canada 2002a). [115]

Canada's Green Plan is the national strategy for sustainable development launched by the federal government in 1990. The Green Plan was developed through extensive consultations from government, business, interest groups and the public. The goal of the plan is ‘to secure for current and future generations a safe and healthy environment, and a sound and prosperous economy’ (Environment Canada 1995) The plan addresses a range of environmental issues that were relevant to Canada in this period and highlighted the need to incorporate sustainability into all aspects of decision-making.

The Green Plan developed at a time when public awareness of environmental issues was increasing, significant environmental degradations were affecting communities, and an international agenda was forming through the basis of *Our Common Future* and UNCED (Environment Canada 1995; Environment Canada 1996). The plan committed resources, set targets based on the consultative process, and was an important policy shift for all Canadian governments. It set a climate for cooperation on the basis for a coordinated approach. However, balanced against competing objectives and pressures achieving a nationally coordinated approach has been met with difficulty and no single Canadian model has emerged despite a range of efforts at the federal, provincial and territorial levels (Canada. 1991).

A pivotal development in reporting for sustainability followed the amendment to the *Auditor General Act,* with the formation of the Office of the Commissioner of the Environment and Sustainable Development (IISD 2001; Auditor General 1997). As a result all federal ministers are required to present sustainable development strategies for their departments that are tabled in

[115] The mandate of the NRTEE is “*To serve as a catalyst in identifying, explaining, and promoting the*

Parliament. To assist, the Commissioner's office has released *A Guide to Green Government* (Government of Canada 2002c). It includes objectives and policy tools to develop sustainable development strategies. Departmental strategies must be prepared every two years with the Commissioner reporting annually to Parliament on the results and progress. This process represents a step towards implementation of sustainability objectives into the Government. A set of 29 strategies was tabled in Parliament in February 2001 for the period 2001-2003 (Commissioner for ESD 2001). Another role of the Commissioner is that of overseeing a process where the public can seek explanation from a Minister for a decision on a relevant sustainability issue. This builds an element of accountability and transparency into decision-making (Commissioner for ESD 2001).

Continuing challenges remain for the implementation of sustainable development in Canada. These include jurisdictional fragmentation, incomplete data and information, competing priorities and the lack of standards. While at a strategic policy level, several important initiatives have been launched; their implementation at a practical level amongst competing sectors remains a significant hurdle.

5.3 Management of Fisheries and the Marine Environment in Canada.

In Canada, the federal government has authority over the oceans and their resources. Provincial and territorial governments have jurisdiction over shorelines, some marine areas, and land-based activities including fish processing and aquaculture (Dobell and Charles 2002; Haward et al 2002). The federal Minister of Fisheries and Oceans, through the Department of Fisheries and Oceans (DFO) is the lead agency with respect to oceans policy and fisheries (DFO 1997a; Haward et al 2002). It has the legislative responsibility for the administration and enforcement of the *Fisheries Act* and the *Oceans Act* 1997. The sustainable use of fishery resources remains a primary focus of oceans-related activity for Canada. Stock conservation problems, allocation conflicts, transboundary disputes, and excessive harvesting capacity have combined to encourage the federal government to pursue a strategy to advance industry restructuring and to introduce changes to policy and management (Earth Summit 2002, Haward et al 2002). Canada is guided in this undertaking by the following principles: conservation comes first; aboriginal rights must be respected; industry capacity must be balanced with the sustainable carrying capacity of the resource; and, government and industry must move towards operating in

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practices of sustainable development"(Canada. 1995).

partnership with one another (Dobell and Charles 2002). In addition, provincial and territorial governments are working cooperatively with the federal government to improve policies to strengthen fisheries management (DFO 1997a).

The *Fisheries Act* is the legislative basis for the conservation, protection and management of fisheries and habitats, licensing, enforcement, and international fisheries agreements (DFO 1997a; OECD 1997a). The Act gives government powers to “make all and every such regulation or regulations as may be found necessary and expedient for the better management and regulation of the Fisheries.”(DFO 1997a).

Management under the Act involves the development of integrated fishery plans, policies and programs to ensure ‘sustainable’ utilisation and distribution of quota amongst a variety of users (DFO 1997a). Management tools include traditional use of input and output controls such as quotas, gear restrictions, season closures, and regulating and enforcing licensing conditions (OECD 1997b). The use of particular approaches is dependent upon the location, stock, gear and regional socio-economic consideration. In addition DFO engages in stock assessment and protection activities for commercial target species (DFO 1997a).

One of the primary tools that the DFO uses in managing commercial stocks is the Integrated Fisheries Management Planning process leading to Integrated Fishery Management Plans (IFMP). IFMPs were introduced in 1995 to orientate fisheries management towards co-management influenced objectives (DFO 2002). The purpose of IFMPs are to achieve consistency in management processes for all Canadian fisheries, integrate complex management factors within a cohesive framework, and provide a planning system, multi-year where possible, for the sustainable use of the resource (DM Consultants 2001).

IFMPs identify objectives and establish rules relating to research and management of the commercial fishery, establish protection and conservation measures, and set rules for the allocation of the resource amongst users and fleets. (GTA Consultants 1998). IFMPs have been used as operational tools to implement co-management objectives in Pacific and Atlantic fisheries (Auditor General 1999).

Integrated Fisheries Management Planning, as a process, establishes consultation and information exchange mechanisms for the stakeholders in the fishery that includes industry and professional organisations, conservation and indigenous interests. In addition the IFMP process aims to coordinate inputs from DFO internal departments (Resource Management, Science, Conservation and Protection, Aboriginal Affairs, International, Oceans and Policy) into fishery planning (Auditor General 1999). The resulting IFMP includes [116] (Auditor General 1999):

- Overview of the fishery and its participants;
- Biology of the stock, conservation issues and research activities;
- Identification of the main management and conservation objectives and requirements for the fishery;
- The management measures that will be used to achieve these objectives;
- Indicators that measure success in achieving the objectives;
- Harvest levels and allocations.

The IFMP is an important tool for improving communication to, and involving, all stakeholders in management. The resulting document provides a more comprehensive description of the fishery than previous styles of management planning and establishes multi-year approaches with long and short-term objectives and indicators for review (Auditor General 1999). To this date, this integrated approach has been replacing traditional management plans in all DFO regions across Canada [117].

It should be noted that IFMPs represent an evolving step towards increased decision-making power for stakeholders in co-managed fisheries. The plans are not legally binding documents but do establish and set the basis for licensing and regulatory requirements (DFO 1999a). The development of legally binding Joint Partnership Agreements between DFO and other stakeholders was the basis of legislative changes in the *Fisheries Act* in 1996. However, the legislation ran into opposition in parliament and was not passed. Despite this fact, Joint Partnership Agreements remain a significant and ongoing policy issue for Canadian fisheries (DFO 1999c; Government of Canada 2001c). Ongoing debate over co-management mechanisms and increased stakeholder decision-making power is continuing in forums such as the Atlantic Fisheries Policy Review (Government of Canada 2001b) and will remain a significant ongoing feature of future fisheries management reform.

The approaches used in fisheries management planning under the *Fisheries Act* (including

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[116] See DFO (1999a) for a detailed descriptive list of the components of an IFMP.

[117] For example, in the Pacific region, strategy for implementation was to develop 12 pilot IFMPs in 1999 and 2000, and using the experience gained, in late 2000 develop a plan to establish IFMPs for the rest of the region's estimated 40 fisheries management plans. However, by December 1999 all but 2 of the region's active plans were scheduled for IFMP development before January 2001 (Government of Canada 2002c).

IFMP) generally employ a single target stock (and dependent habitat) approach. However, emerging pressures from the community and policy expectations set by sustainability identify integrated ecosystem-based management as the challenge for fisheries management. Objectives based fishery management (OBFM) is an approach under development within DFO to include broader socio-economic and environmental concerns within IFMP. The methods behind this approach are expanded and assessed in the case studies below. In addition, the *Oceans Act 1996* expands the role of DFO to take account of sustainability and ecosystem considerations with enabling legislation that attempts to integrate all ocean use activities and users, including fisheries (Government of Canada 1996).

Parliament passed the *Oceans Act* in December 1996 (Government of Canada 1996). The Act represents a significant step by the federal government to establish and manage the extent of Canada's oceans jurisdiction. The Act declares Canada's maritime zones in accordance with the provisions of UNCLOS, provides for the development of a national oceans management strategy, and provides for the consolidation and clarification of federal responsibilities for oceans management (Government of Canada 1996).

The *Oceans Act* establishes a legislative commitment to sustainability, integrated ecosystem based management, precautionary approaches, and community participation. The challenge set by the legislation lies in how the commitment can be interpreted and applied in practice.

The *Oceans Management Strategy* is the vehicle chosen to implement the Oceans Act.[118] Addressing objectives within Chapter 17 of Agenda 21, the strategy is based on the premise that oceans management must be based on a collaborative effort among stakeholders (Communications Directorate 1997). The strategy allows for the development of flexible approaches on that can be implemented regionally and based on the principles of sustainable development (Government of Government of Canada 2002b). The strategy sets three objectives that require action:

- Understanding and protecting the marine environment
- Supporting sustainable economic opportunities; and
- International leadership and governance.

[118] Under Part 2, Sections 28-39 (Government of Canada 1996).

DFO has committed to over sixty initiatives over four years to achieve the objectives and implement the strategy (Government of Canada 2002b). Several initiatives are of direct relevance to fisheries and include the development of marine protected area networks, a Marine Environmental Quality policy and operational framework, new reporting approaches such as a State of the Marine Environment reports, measures to protect fish habitat, industry development, international oceans governance issues, and developing Large Ocean Management areas (Government of Canada 2002c). DFO as the lead authority for oceans and fisheries management will face several complex challenges over the integration of fisheries management tools (such as IFMP & OBFM) with broader ocean use policies. Integration will present challenges to the DFO internal departmental structure, and management relationships with external stakeholders.

The notion of integrated management planning (IMP) is perceived as the primary governance mechanism to apply sustainability, integrated and precautionary principles under the Oceans Act (DFO 2002). A recently released a discussion paper outlines the principles, objectives and operational guidelines for the development of integrated oceans management plans (Government of Canada 2002c). The strategy (Government of Canada 2002c) defines Integrated Management as:

- A comprehensive way of planning and managing human activities so that they do not conflict with one another; so that all factors are considered for the conservation and sustainable use of marine resources and shared use of ocean spaces;
- A collaborative approach that cannot be forced on anyone;
- A flexible and transparent planning process that respects existing divisions of constitutional and departmental authority, and does not abrogate or derogate from existing Aboriginal or treaty rights.

IMPs are not homogenous instruments. The composition of the plans and management arrangements will depend on the scale and complexity of the issues, local and regional infrastructure and capacity, and the level of community concern. Plans have been initiated in the Arctic Ocean (Beaufort Sea Integrated Management Planning Initiative), the Atlantic Ocean (Eastern Scotia Shelf Integrated Management (ESSIM) Initiative), and the Pacific Ocean (Central Coast of British Columbia initiative) (Government of Canada 2002c).

The oceans agenda sets significant challenges for fisheries management. Over the last 10 years management has faced challenges from declining commercial stocks, and from socio-economic and/or environmental pressure. The collapse of the Atlantic ground fishery and resulting economic and social impacts in provincial communities served as a catalyst to review fisheries management procedures (Harris 1995). As a result, several innovative arrangements have been initiated that aim to improve cooperative assessment and management of stocks.

The Fisheries Resource Conservation Council (FRCC) was established in 1993 marked an innovative departure from traditional fisheries management (Charles 2002). The FRCC is a partnership between scientific, academic and industrial stakeholders for Atlantic fisheries. The FRCC, as an advisory body, makes public recommendations to the Minister of Fisheries and Oceans on such issues as total allowable catches, conservation measures, and priorities for scientific research (FRCC 2002; Charles, 2002). Stock assessment information is provided to the FRCC who provides a series of recommendations to the Minister after consulting all interested stakeholders in the fishery. The Minister then makes the decision on TAC and conservation measures (Charles 2002). The FRCC is an example of an innovative consultative approach that increases accountability in the management of Atlantic fisheries. The initiative has been exported to the west coast in the form of the Pacific Fisheries Resource Conservation Council.

5.4 Sustainability Indicator Systems in the Canadian Fisheries Sector.

In reporting to the United Nations Commission for Sustainable Development in 2001 (Government of Canada 2001c) the Federal government acknowledged that indicators are:

> *Useful integrative tools that measure our progress toward sustainable development and signal whether we are heading in the right direction. They provide a bridge between the detailed data found in core data sets and interpreted information.*

Indicators are recognised as useful tool in fisheries management for interpreting and applying ecosystem and precautionary objectives, and converting these to measurable criteria. A range of government and inter-governmental approaches has been identified as the basis of this case study and scored against the assessment framework.[119]

Despite support for and significant work on indicator systems, they are in a stage of initial development and application within the fisheries sector. Canada has established broad national reporting programmes such as the National Environmental Indicator Series (NEIS) and the National Roundtable on Environment and Economy (NRTEE) that represent collaborative, intra-

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[119] These case studies do not represent the only initiatives to assess fisheries sustainability. Other progressive examples include Charles et al 2002, and RAPFISH by FAO (1999c).

governmental approaches that report on a range of issues, including the marine environment. These systems, while generally lacking in detailed sector specific information, aim to report at a broad decision-making levels, complement traditional economic indicators, and to inform national debate.

With a shift towards sustainable oceans management DFO is developing a Marine Environmental Quality (MEQ) and ecosystem-based management indicator system as a part of the implementation of the Oceans Act. While not directly related to fisheries management at this point in time, these systems will play a pivotal role in integrated oceans management – including fisheries. As a part of the DFO approach to broadening fisheries management, the department has developed a national Objectives Based Management approach (OBFM) to account for socio-economic and environmental issues in fisheries planning. How the broader integrated oceans initiatives will relate to fisheries initiatives is not yet clear, but it is likely that they will generate a broad framework for sustainable use and consultation in large marine ecosystems and while at the same time preserving the legal authority of fisheries management.

In addition to national approaches there have been significant advances under regional management arrangements within DFO. One such advance is the use of the Traffic Light Approach (TLA), an indicator system developed by the DFO Maritimes. The TLA has undergone significant debate within this regional authority and has been applied to the Atlantic groundfish and crustacean fisheries with significant management outcomes. The TLA represents an advanced approach to using a SIS in direct fisheries management and completes the spectrum of approaches within this case study.

Despite stakeholder acceptance and relatively advanced status of indicator systems in Canada several hurdles remain for establishing effective use. The identification, collection and use of data for indicators is still a major problem for fisheries. Measuring change towards sustainability objectives suffers from inadequate baseline data; oversimplification within PSR type models and exposure to predictive limitations within SIS. Coordination of indicator research remains a huge challenge within departments, between departments, and between government and other stakeholders. The output aspects of indicator systems are still relatively unknown ground with communication, aggregation, and the use of the results in decision-making a challenge for managers.

5.4.1 The relevance of the case studies to the thesis

The identified sustainability indicator systems represent recent developments in marine and fishery sustainability reporting in Canada. The systems have developed through national reporting frameworks, intra-governmental collaborative approaches and broader oceans and sectoral fisheries management planning mechanisms.

The common factor amongst the varying approaches is the commitment to implementing sustainability principles into practical outcomes for decision-making and informing stakeholders. The level of implementation ranges across these cases, but all systems have the baseline of a reporting framework, criteria and initial set of indicators. These cases are observed as highly relevant for this thesis and present a cross section of initiatives across Canada that will be examined in the analytical framework.

5.5 Case 4. National Environmental Indicator Series

5.5.1 Background

Canada's *Green Plan 1990* established the policy commitment to develop a series of national environmental indicators and a federal state of the environment reporting process. This has evolved over the last ten years with a national state of the environment report (Government of Canada 1991), a national vision for reporting[120] (NRTEE Steering Group 2001), the development of a series of provincial and regional level theme reports and the National Environmental Indicator Series. State of the environment reporting is recognised across the federal government as an important tool in integrated environment and economic decision-making (Government of Canada 1991). The State of the Environment InfoBase, housed by the Indicators and Assessment Office in Environment Canada, houses a central database for national environmental reporting initiatives and dissemination of information to the public (Vandermullen 1998; Government of Canada 2002a).

Initial discussions over the development of a National Environmental Indicator series (NEIS) were initiated in 1991 with the release of a draft set of 43 preliminary indicators in 18 issue areas (Vandermullen 1998). This set of indicators provided the basis for consultations with federal and provincial departments, NGOs, and private sector stakeholders over the format of a national set.

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[120] The vision was prepared on the basis of a MOU between key natural resource agencies. The agencies are Agriculture and Agri-Food Canada, Environment Canada, Fisheries and Oceans Canada, Health Canada, and Natural Resources Canada.

This process was Canada's initial drive into the development of sustainability indicators that report on issues of 'national significance'. The development of the series provided a basis for consultation and research into the challenges set by 'translating and delivering concise, scientifically credible information in a manner that can be readily understood and used by decision makers at all levels of society' (Government of Canada 2002a). NEIS generated outputs as a series of bulletins from 1998 containing indicators, results and interpretations from key issues. The series has been superseded by other initiatives but continues to set the basis for the development of national indicator series.

5.5.2 Structure and Indicators

The National Environmental Indicators Series is a thematic based framework designed to assess a range of profile issues that contribute to (or away from) sustainability. It employs a modified version of the pressure-state-response model developed by (Friend 1979) for ordering the indicators under each issue.[121] NEIS fits the SIS model structure identified in Chapter 3 - an identified hierarchical structure, a broad definition split into specific dimensions (or issue areas) of sustainability with subsequent unpacking into criteria and indicators. The SIS gauges progress towards or away from sustainability based on the status of several key profile issues.

The Indicators and Assessment office has identified three environmental dimensions for sustainable development.[122] They include: assuring ecosystem integrity, assuring human health, and assuring natural resource sustainability (Government of Canada 2001c). In addition, another dimension representing socio-economic pressures have been included in the framework. Together the four dimensions provide the strategic basis for the profile issues. Under each dimension, a list of issues has been identified that represent the more specific elements of sustainability to be measured by indicators. Issue selection was through consultative processes with government and stakeholders and identified policy priorities such as Canada's Green Plan 1990 (Vandermullen 1998; Government of Canada 2002a).

The dimensions and criteria of the SIS are listed in Table 14.

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[121] In this case the framework is called the stress-condition-response model, based on the PSR framework described in Chapter 3.

[122] Based on Canada's Green Plan priorities.

Table 14. Broad dimensions and issues in the National Environmental Indicator Series

Broad Dimension	Issues
Ecological Support Systems	Stratospheric Ozone depletion
	Climate Change
	Toxic contaminants in the Environment
	Acid Rain
	Biodiversity Change
	Ecosystem Health
Human Health and Wellbeing	Urban Air Quality
	Urban Water
	Freshwater quality
	Urban Green Space
Natural Resources Sustainability	Sustaining Canada's Forests
	Sustaining Marine Resources
	Agricultural Resources
Pervasive Influencing Factors	Canadian Passenger Transportation
	Energy Consumption
	Population Growth and Lifestyle Patterns
	Solid and Hazardous Waste Generation.

(Adapted from Vandermullen 1998)

For each issue, a variant of the Pressure-State-Response framework is applied to identify measurable indicators. Sets of generic indicators are identified that fit the framework and provide a quantitative measure and appraisal of the status of the issue. Each indicator is filtered to assist in determining its effectiveness. This includes testing on sensitivity to change, reliable data, collection methods, and acceptance by users (Environment Canada 1998).

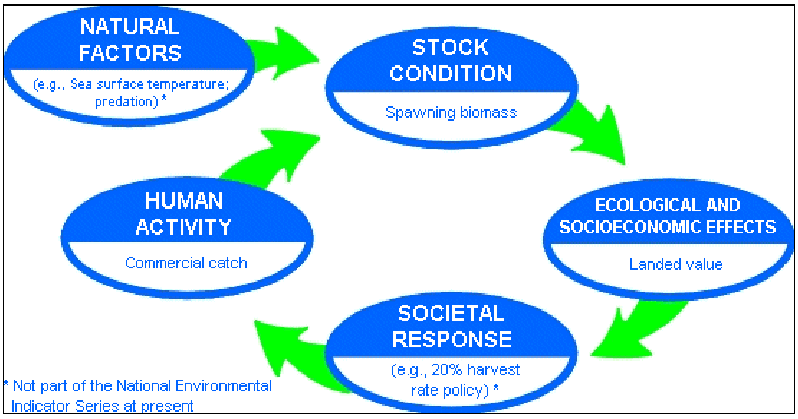
The National Environmental Indicator Series reports on fisheries through the Natural Resources Sustainability: Sustaining Marine Resources component. Applying the stress-condition-response model to the fisheries domain generated the indicators listed in Table 15 below.

Table 15. Sustaining Marine Resources Indicators (Environment Canada 1998)

Stress	Condition	Response
Natural factors: Sea surface temperature.	Stock condition: spawning biomass	Management Response, TACs & exploitation rates.
Human activity: commercial catch	Socio-economic: Landed value.	Expenditure.
Habitat pressure	Socio-economic: Employment	

Stress indicators include a measure of significant natural forcing (in this case sea surface temperature) and human impact upon the fishery (commercial catch). Condition indicators examine the state of the target species (spawning biomass) and economic status (landed value) at a fixed point in time. The response indicator, which was not included in the set due to a lack of data at the time, attempts to capture the management response. This can include the setting of Total Allowable Catches and altering the exploitation rate. Although implying linear relationship among these variables can lead to incorrect assumptions about fisheries dynamics, the framework presents a simple way of reporting a fishery system in a national context (Figure 33). The aim of the marine resource indicators in the NEIS is to capture a profile or 'snapshot' of key fisheries that can be presented to the public and decision makers (Vandermullen & Cobb 2001). This is an important consideration as a small set of indictors can only reveal limited information about the fishery. A limited indicator series such a the NEIS must identify the target audience and present effective indicators that are useful for this audience, in this case, an overview of the status of key commercial stocks.

Figure 33. The NEIS framework in the context of fisheries indicators.



5.5.3 Status

The NEIS aimed to report on significant commercial fisheries on the east and west coasts with the view to establish a broad overview of national fisheries status. The only fishery to undergo full assessment and publication through a bulletin has been the west coast Pacific Herring fishery in 1998. The fishery is a significant employer in British Columbia and the west coast and contributes significantly to the regional and national economy (Environment Canada 1998). In addition, a draft bulletin on Atlantic invertebrates (lobster, snow crab and northern shrimp) that contains indicators of stock biomass estimates, commercial catch, landed value of catch, and total employment for harvesting and processing was under review in 1998 but did not progress past this stage (Vandermullen 1998). A draft bulletin on Pacific Salmon stocks was proposed that included indicators of populations at risk, spawning biomass, commercial catch, economic value of recreational fisheries, and enhancement program expenditures (Vandermullen 1998).

It is important to note that the NEIS was Canada's initial foray into indicator use that included marine resource assessment. It established significant experience in developing reporting systems for sustainability across key sectors and disseminating this information to users. The NEIS has served as a basis for ongoing discussion and refinement of indictor systems and been an influence in the external reporting of broader marine indicators.

5.5.4 Scoring against the assessment framework

Table 16 and Figure 34 (a-e) score and graph the case against the assessment framework. Against Strategic Outcomes (Figure 34a) the NEIS scores low in the focus system component (1) and an average result (2) against the contribution to societal sustainability. The system employs a generalist approach that simplifies the fishery in order for it to be included in a broader multi-issue based report. Generalisation of the issue facilitates ease of assessment and communication but can mask more specific or localised factors that are significant in influencing the system. A balance must exist between simplification and detail in sustainability reporting. The NEIS generally trades simplicity for ease of reporting and maximum coverage, and places the fishery in the broader context of national environmental issues and a reporting system to assess the states of these issues.

In terms of System Processes (Figure 34b) the NEIS maintains an above average score in its core structure (2.3) but scores comparatively low the sub-structure, input processes and output processes. The SIS uses a strong thematic and P-S-R framework as a basis for identifying issues, subdividing into criteria and selecting indicators for reporting. However the sub-structure does not particularly support the core structure with vague objectives, use of proxy indicators and minimal performance measures. The NEIS maintained irregular reviews and limited feedback resulting in the low input score. For outputs, the SIS scored high for visualisation and communication from an innovative web interface, but was lowered to a below average score (1.5) due to a lack of decision making influence and aggregation (see Table 16).

In terms of policy attributes for sustainability (Figure34c), the SIS has average scores in integrative capacity, project management and participation (2). Adaptive management scores low (1) as the SIS contained a basic, informal monitoring program with minimal use of socio-economic indicators and minimal use of institutional indicators. Improvements in the development and use of these classes of indicators, increased participation and buy in, and institutional support would improve the use of the SIS.

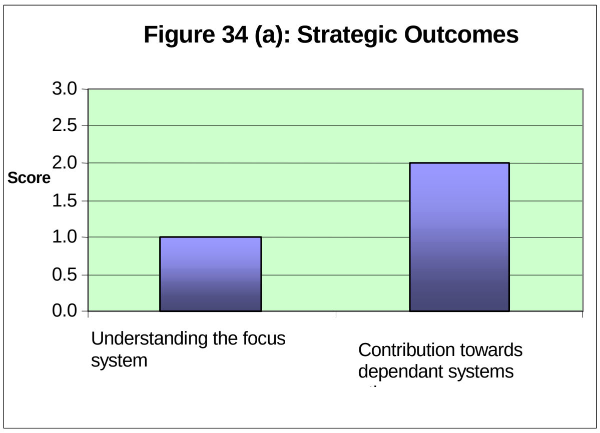
In Figure 34d, orientation chart shows Fisheries Issues in the SIS are low overall and tend to focus on the target species (2), maintain a basic relationship to fisheries management by being a reporting tool (2), and has context sensitivity by reporting on key economic fisheries (2). The development of ecosystem based management principles; recognition of external influences and formal recognition of uncertainty would improve the SIS outcomes.

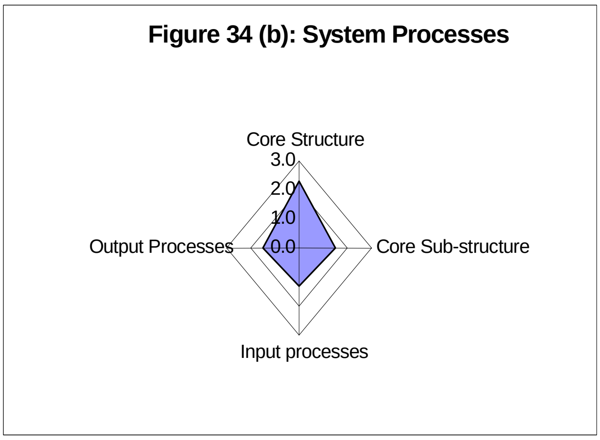
Not surprisingly, the Case Aggregate (Figure 34d) reveals a low scoring system with the highest scores originating from the System Processes and System Features. Clearly, an improvement in the information on fisheries issues would improve the NEIS approach. It must be noted however that this approach was a pioneering attempt at using indicators and frameworks to report on environmental issues. There was a general lack of available information and experience in developing SIS and providing the basic information requirements. Consequently, the low scores against the conceptual framework represent a snapshot back in time and a developmental fishery SIS that has been superseded by recent approaches such as the NRTEE.

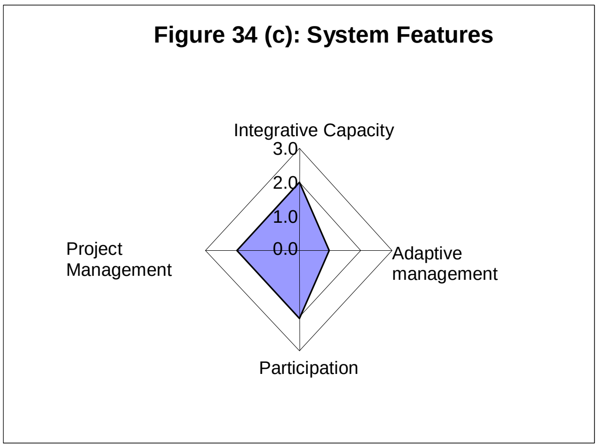
Table 16. Case 4 Scoring.

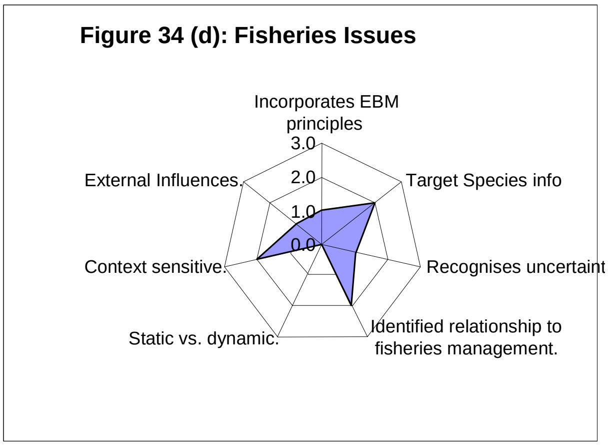
Case 4 National Environmental Indicator Series (NEIS).				
Strategic Objective	***Sub Objective***	***Operational Objective***	***Score***	***Notes***
1. Strategic				
	Understanding the focus system	*System state and viability*	1	Generalist, basic approach. Simplified assessment nder PSR model.
	Contribution towards other dependant systems	*System contribution to broader societal sustainability.*	2	The approach nests within a issue based assessment - e.g. forests, water, atmosphere. Table 14.
2. System Processes				
	Core Structure	*Interpretation and definition of sustainability.*	2	Broad definition that focuses on ecosystem health, human impact, resources, and socio economics.
		Framework classification.	3	Framework based on issues then ordered by the PSR framework. Figure 33.
		Dimensions of sustainability.	2	Broad dimensions of human and enviornmental wellbeing, resources and influencing factors
		Criteria and sub-criteria.	2	Issue based critera, further developed on PSR model. Fisheries limited in scope.
	Core Sub-structure	*Objectives*	1	Broad objectives exist lack of specific operational objectives for each indicator.
		Indicators: Scientific	1	Use of proxy indicators. Limited set (5 indicators).
		Indicators: Functional	3	Highly pragmatic, useful and understandable indicators.
		Performance values	0	No perfromance measures.
	Input processes	*Policy context*	2	This was an early approach. No consensus on how the SIS interacts with decision making.
		Indicator feedback	1	Irregular review.
		Stakeholder / user feedback	1	Limited feedback into the process.
	Output Processes	*Visualisation & presentation.*	3	Effective visualistion for Herring example. Web based reports. Accessible.
		Communication & reporting	3	Web based reporting. Accessible and understandable.
		Aggregation and scorecards	0	No methods for aggregation.
		Decision making influence	0	No decisio making influence.
3. System Features				
	Integrative capacity	*Interaction of sustainability dimensions.*	2	The interaction of different systems is recognised. No mechanisms to formally quantify.
		Integration with other reporting systems and sectors	2	The information form the SIS was exported to broader fora. Limied info available.
	Adaptive management	*Social indicator development.*	1	Basic use of socio economic indicators, standard approaches e.g. value and landings info.
		Institutional indicator develop.	0	No use of institutional indicators.
		System monitoring & feedback	2	Initial monitoring of system and inclusion of new indicators. System replaced by MEQ and NRTEE.
	Participation	*Participation of stakeholders*	1	Minimal participation and top down approach.
		Participation of decision makers and relevant institutions.	3	cross linkages between Federal Depts - DFO, Env. Canada. Led into the NRTEE process.
	Project Management	*Institutional Capacity*	1	sufficient capacity. SIS lacked buy in and coordination.
		Marketing and R&D	3	Strong marketing approach via Green Lane & Canada EIA website.
4. Fisheries Issues				
	Incorporates EBM Principles	*SIS reflect broader ecosystem based management principles.*	1	General lack of EBM principles and indicators.
	Target Species info	*Indicators assess state of the target stock , used in management plans.*	2	Target sp. Indictors present but uncertainty over the outputs into mgt.
	Recognises precaution	*Assessments explicitly recognise all forms of uncertainty.*	1	Uncertainty recogised but not accounted for or assessed.
	Identified relationship to fisheries management.	*Indicators feedback to mgt.*	2	Focus on an information tool for informing stakeholders and decision makers.
	Static vs. dynamic.	*Static and dynamic reporting within SIS.*	0	Snap shot approach. Annual review.
	Context sensitive.	*Does the SIS take specific fishery context isues into account?*	2	Focus on specific fisheries of socio-economic importance.
	External Influences.	*Inforrmation on overcapacity, subsidies, trade, fleet structure, IUU fishing and external influences.*	1	Minimal recogntion of fisheries external influences (e.g. landed values). Minimal indicators.

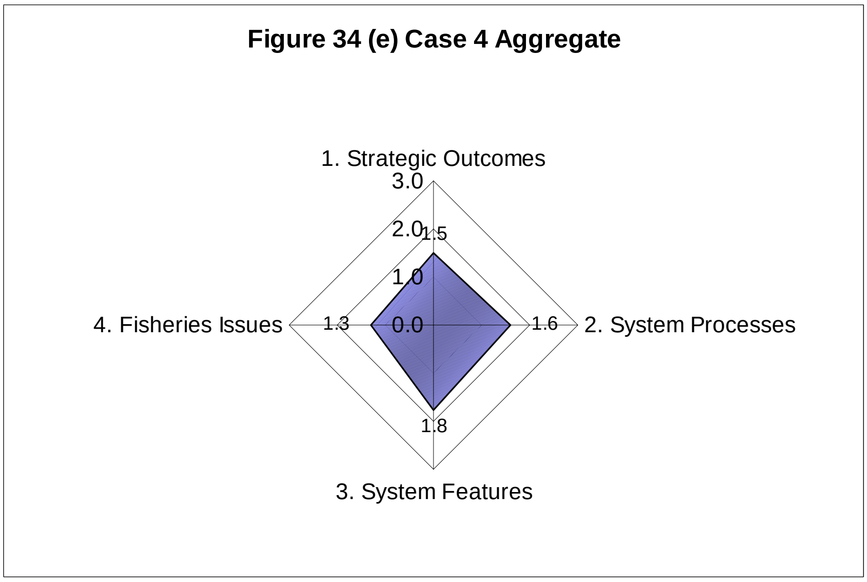
Figure 34 (a-e) Orientation graphs for Case 4











5.6 Case 5. National Round Table on Environment and Economy: Environmental and Sustainable Development Indicators Initiative.

5.6.1 Background

The National Round Table on Environment and Economy (NRTEE) is an independent body that provides advice to the Canadian government and the public over issues related to sustainable development. The NRTEE has established a task force on issues related to fisheries and oceans management [123] and the development of indicators.

The Environment and Sustainable Development Indicators Initiative (ESDI) commenced in 2000, commissioned as a three-year project by the Minister of Finance in the 2000 federal budget (NRTEE 2002b). The ESDI begins where the NEIS (Case 4) finished, developing a national set of robust indicators that are used in decision-making and policy analysis. An innovative development in the ESDI program is the commitment that the indicators be used as supplements to traditional economic indicators such as the Gross Domestic Product (NRTEE 2003). The initiative has released an initial set of indicators (NRTEE 2003) and is an emergent and important contribution to integrating sustainability concerns into core economic decision-making.

The outcomes of the ESDI Initiative are identified as follows (NTREE 2003):

- A framework for a set of national indicators and accounts to provide a complete account of Canada's capital;
- A preliminary set of core indicators that are feasible in the short term;
- Identification of other possible indicators and data needed to complete the framework in the medium and long term;
- Recommendations for a series of accounts that provide complete tracking of Canada's capital in both monetary and physical units and show linkages between different forms of capital.

Progress towards these outcomes is through three phases of development, beginning in 2000. The first phase of the ESDI project developed the scope and framework for the SIS. This

[123] The NRTEE has established an Ocean Environment and Resources Task Force that deals with fisheries ad oceans matters with the objective of examining the relationship between those who regulate and those who use the resource NRTEE(1996).

developed the philosophy behind the ESDI initiative, described as the ‘capital approach.’ This is expanded below. In the second phase the priority is to develop a series of indicators that can be applied to the framework while the third phase will focus upon testing and applying the SIS and engaging in public consultation (NRTEE 2002b; NRTEE 2002c).

To develop indicators that are relevant and useful to stakeholders, the ESDI is split into ‘cluster groups’ that are composed of experts from industry, academia, government and non-government organisations. Each cluster group investigated the development of indicators, issues of aggregation, and application of indices to decision making. NRTEE cluster groups are in six domains: renewable natural resources, non-renewable natural resources, land and soils, water resources, air quality and atmospheric conditions, and human capital. The renewable natural resources cluster includes experts from the fisheries and forestry domains. Cluster groups are coordinated by a steering committee with support from Environment Canada and Statistics Canada to develop the SIS as a whole (NRTEE 2002c).

One of the innovative departures of the project has been to investigate the issue of aggregation and the development of an overall ‘index of sustainability’ (Hanna 2002; Stratos Inc 2002). Debate has centred on the common metric of monetary valuation of human and natural resources (Smith 2001), substitutability of these resources (Smith 2001), and the aggregation of common metrics into a single measure (Stratos Inc 2002). Proposed outputs include a single aggregated measure (eg. a Total National wealth indicator) to a highly disaggregated set.

The debate within the NRTEE workgroups has revealed a fundamental issue within indicator systems - that common valuation and aggregation of diverse natural and human criteria is a difficult task that has yet to be reconciled in most initiatives. The economic workgroup recommended a normalised aggregated approach based on monetarisation whereas the cluster groups indicated that monetarisation left out important details, the valuation is inherently difficult, and that diverse groups of resources could not be substituted (NRTEE 2002b; NRTEE 2002c). The implication within the ESDI initiative is that at this point in time, aggregation will not occur across all indicator domains.

5.6.2 Structure and Indicators

The NRTEE ESDI initiative takes a departure from the traditional definition of sustainability by employing a framework based on the notion of *capital* (Smith 2001). The capital approach is the first step in setting the framework for the SIS and guides the selection of all indicators (Hanna

2002). This approach has been labelled as robust and practical, allowing integration with traditional economic reporting, availability of information for indicator development and has been utilised in other indicator systems.[124]

Capital is defined as the range of assets that support an ability to produce a variety of goods and services that facilitate economic activity and human development over time (Smith 2001) (NRTEE Steering Group 2001). The sustainability of a nation in terms of long-term socio-economic and environmental well-being is directly tied to the maintenance of different forms of capital. NRTEE indicators track different forms of capital and contribute to decisions about the extent, availability and management of these resources. The indicators assess not only the state of current economic activity but aim to assess trends in the use of, and investment in, the stocks of the different forms of capital (NRTEE Steering Group 2001).

The approach broadens the traditional economic view of capital from purely market tradable, produced goods and services to include all produced, natural, human, and social forms - all necessary components of sustainable development (NRTEE 2003). This expanded notion of capital is essential for developing indicators that assess the integration of economic, environmental and social concerns and link intra and inter-generational equity [125] to the SIS. Equity is an issue that has remained elusive in terms of indicator development to date. However the ESDI initiative, with a focus on the current state and future trends of capital, can investigate the maintenance of these goods and services (and the tradeoffs involved) for current and future generations.

The ESDI initiative identifies the different forms of capital as follows (NRTEE 1996; NRTEE 2002b):

Produced Capital: produced goods that provide benefits to their owners over time by helping produce other goods and services. Produced capital has extensive data available in economic accounts and an associated indicator 'maturity'.

Natural Capital: The stock of assets provided by the environment, comprising natural resource stocks, land, and ecosystems, and biological diversity. Natural capital provides economic options

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[124] *Wealth of Nations* by the World Bank, *Sustainable Development Indicator Initiative* in the U.S. and the *Genuine Progress Indicators* in Canada all employ the capital approach (Smith 2001).

[125] Intra and inter-generational equity, is a core objective of sustainable development as identified in Chapter 2. It relates to the equitable distribution of goods and services within the current generation and the maintenance of goods and services, and options for development, for future generations.

for current and future generations: resources provide the raw materials used in the production of manufactured goods and in the provision of services; economic activity occurs on land; and ecosystems provide numerous essential services, e.g. clean water and air, productive soil, waste assimilation, amenity and well-being.

Human Capital: The knowledge, skills, competencies and other attributes embodied to individuals that facilitate the creation of personal, social and economic well-being.

Social Capital: Identified as relationships, networks and norms that facilitate collective action, formal and informal institutional relationships.

The dimensions of the capital approach form the basis of the SIS framework.[126] In Figure 35, the framework employs a hierarchical structure, with national capital split into the dimensions of social, human, natural and produced capital. The dimensions are further split into criteria that directly guide the selection of indicators. Natural capital is split into five criteria: renewable resources, non-renewable resources, air resources, water resources, and land resources. The renewable resource criterion hosts the indicators for fisheries and forest resources[127].

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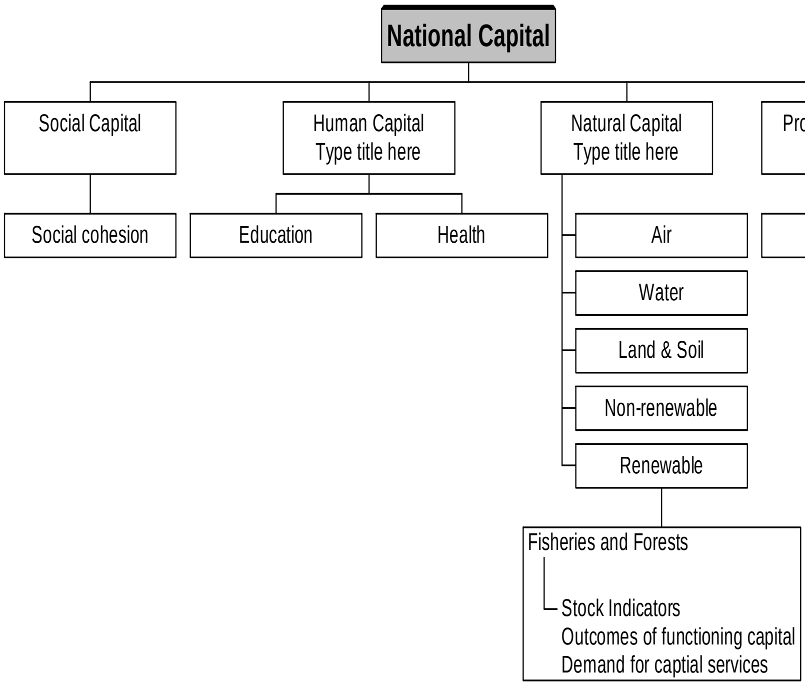
[126] The NRTEE ESDI initiative committee held an ongoing debate over the merits of the capital approach. The debate focused on broader ecocentric views and the inherent and ecosystem values that are recognised within capital resources, and that these values, while important, are difficult to quantify or value. However they do form a part of the sustainability mosaic and must be included in any a set of indicators that gauge a nations sustainability. As a result the capital approach has been modified to include other measures of quality in addition to expressing quantity and aggregations expressed in monetary terms.

[127] The ESDI initiative set the mandate of the Marine and Forest Resources group to Hanna (2002):

- Establish a small set of core indicators for marine and forest resources, giving priority to implementation in the short term, while also identifying indicators feasible in the long term;
- Identify supporting indicators that would help provide context for interpreting core indicators;
- Advise on data requirements ad sources, and on valuation and measurement methods for each indicator;

Figure 35 The framework of the ESDI Initiative.



Under the capital approach, a typology of indicators was developed to organise the set and filter from a wide selection of identified fisheries indicators currently in use in other jurisdictions (DM Consultants 2001). Indicator categories that were identified included (Stratos Consulting. 2002):

- *Capital Stock Indicators:* Quantity of capital; Quality of capital.
- *Outcomes of Functioning Capital:* Ecosystem services; Ecosystem health.
- *Demand for Capital Stocks:* Measures of demand and pollutant loadings.

This starts with the most direct measure of capital stocks (quantity and quality) and proceeds to increasingly indirect measures of capital (ecosystem outcomes and demand). It is important to note that a measure that does not provide a direct account of capital is still useful for analysis of its contribution to sustainability. This has been a recurring feature throughout the ESDI initiative, indicators have focused on measuring capital, but other non-capital indicators (such as measures of endangered species) are required to make policy relevant decisions. The ESDI initiative recognises that direct measures of capital can be aggregated into indices and used in national economic policy making, but these indicators will need to be supplemented by measures

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- Identify future areas of work, including additional indicators, and indicator concepts or data sources.

of value that do not solely focus on monetarisation and avoid the problems associated with valuation of non-market tradable resources and services (NRTEE 1996).

Using the categories to guide selection three core indicators were selected for fisheries. The indicators are listed below in Table 17. Forestry indicators have been included to represent the total renewable resources cluster and display comparable indicators across sectors.

Table 17. Indicators for the Renewable Resources cluster (Adapted from (Hanna 2002)).

Domain	**Stock Indicators**		**Outcomes of Capital Services**		**Demand for Capital Services**
	Quantity	*Quality*	*Ecosystem Services*	*Ecosystem Health*	Not developed
Fisheries	Exploited stock indicator.			Range Occupancy Indicator	Not developed
				Index of VTE species.	
Forestry	Total forest area.	Sustainable forest management		Carbon budget	Not developed
				Index of VTE species.	

Three indicators have been chosen to represent fisheries sustainability. They include the exploited stock indicator, a range occupancy indicator and a VTE species index.[128] The exploited stock indicator is a proxy indicator for measuring the quantity of the stock, in the absence of reliable stock data such as MSY for commercial species (Hanna 2002). The concept behind this indicator is to monitor the actual exploitation rates relative to the target exploitation rates[129] of several 'portfolio' fisheries within an ecosystem. The indicator generates an aggregated index that monitors the productive capacity of multiple fisheries, based on harvests that have exceeded the target (or sustainable) exploitation rates (Hanna 2002). The Range Occupancy indicator identifies the extent to which historical habitat is occupied by key fish species as an indicator of ecosystem health. The VTE (vulnerable, threatened and endangered species) index identifies and monitors the status of a representative group of species, and relates to the health of the broader

[128] Vulnerable, threatened and endangered species.

[129] The exploitation rate refers to the fishing mortality experienced by a fish stock over a given period of time. Exploitation is usually represented as a proportion or fraction of the fishable population, which is harvested. The target exploitation rate is accepted to be the 'sustainable' rate for fishery exploitation based on stock life history parameters. Exceeding the target exploitation rate would indicate increasing pressure and possible overfishing of the stock.

marine system (Hanna 2002). At this point, indicators have not been identified for capital quality, ecosystem services and demands. The forest cluster identified timber obtained from sustainable forest management as an indicator of capital quality; the same approach could be taken for fisheries under suitable management or certification programs (such IFMP / OBFM or certified management programs).

The indicators listed for fisheries in the ESDI initiative, while limited in terms of addressing primarily target stock and VTE species, present an innovative approach to issues of aggregation, valuation, and assessment of fisheries within a broader sectoral framework. The ESDI initiative intends to use these indicators as potential measures of sustainability that will supplement traditional economic accounts and influence broader national and economic decision-making.

5.6.3 Status

The NRTEE initiative followed three phases. Phase 1 focused on the development of the conceptual framework and the capital approach, Phase 2 identified and developed the indicators for each dimension, while Phase 3 tested the indicators with case studies, refined the framework and communicated the ESDI initiative to decision makers and the public. The project has completed the third phase and has set indicators that provide the ‘public face’ of the ESDI and provide for the tracking of Canadian capital assets alongside other macro-economic measures. In May 2003 the NRTEE released six indicators as core set to measure some aspects of Canada’s natural and human capital (NRTEE 2003). The indicators include an air quality trends, fresh water quality, greenhouse emissions, forest cover, extent of wetlands and human capital (NRTEE 2003). Fisheries based indicators were not included in the released set, a likely outcome of the proxy nature of the fisheries set and a lack of consensus and information for completing the fisheries indicators. The lack of final indicators was a point of criticism amongst stakeholders in the initiative (Colman 2002). A report by Smith (2003) stated:

“ The NRTEE concluded that, at present, Canada has insufficient data on its natural and human capital assets and on the linkages among environmental, social and economic issues”

It is important to note that in ‘State of the Debate’ report (NRTEE 2003) that marine and biodiversity indicators were recognised as important future developments in the initiative. In particular, an outcome of the NRTEE has been to initiate a process of expanding the System of

National Accounts (SNA) – the set of indicators that serves as the basis of estimating the Canadian macroeconomic conditions and includes the GDP and Balance of Trade (Smith 2003). Specifically, it proposes that the federal government expand the SNA to include new accounts covering natural, human and social capital. So that the basic data needed to construct these accounts are available, the NRTEE has recommended expanding and improving data collection, particularly in the environmental domain. This would include investments in scientific monitoring systems, more thorough use of existing administrative data and the expansion of environmental surveys. Despite the fisheries indicators not being selected for inclusion in the initial NRTEE report, the potential for inclusion into the SNA in the medium term is a likely progression.

5.6.4 Scoring against the assessment framework

Table 18 and Figure 36(a-e) present the scoring for the case study. Against Strategic Outcomes (Figure 36a) the ESDI initiative scores low against understanding the focus fishery system (1) and high in contributing to other dependent systems and to a broader societal notion of sustainability. These scores are relate to the mandate of the SIS, the NRTEE approach has focused on developing a small set of fisheries indicators that deliver information that can contribute to the *capital* based view of sustainability. Hence a limited view of the overall fishery system is obtained. With fishery indicators were left off the final report, the understanding of the focus system receives a low score. The strength of the SIS lies in its ability to contribute to national decision making with the intent and ability to integrate with traditional economic accounts such a the GDP and the possibility of future additions.

In terms of System Processes (Figure 36b), the NRTEE approach scores the maximum value in core structure (3), average in core sub-structure (2) and output process (1.8) and an below average score in input process (1.3). Overall the SIS maintains a highly structured approach in assessing sustainability with a strong definition and framework with ongoing improvements to outputs and core-sub structure. This translates to a guiding definition of sustainability that flows through to a framework (thematic and hierarchical approach) and sets specific criteria and sub-criteria. Objectives are explicitly set in the SIS, and the development of indicators is progressing. The sub-structure was reduced to an average score due to the fact that the SIS has not developed performance measurements for indicators. The development of threshold levels (performance measures) for capital stocks is an area of proposed future development (NRTEE 2002a). For outputs, the SIS is yet to develop a visualisation, but has managed to develop a robust debate on the methods and issues surrounding aggregation of scores (see Table 18). The intent to be used as a national economic measure places aggregation at the heart of the SIS. With ongoing development, the system will generate significant influence in decision-making, a claim to be further investigated in the future. For input processes the SIS scores poorly. While the SIS maintains links to and is based on national core economic and sustainability policies it needs to improve feedback from stakeholder views into the process (Colman 2002).

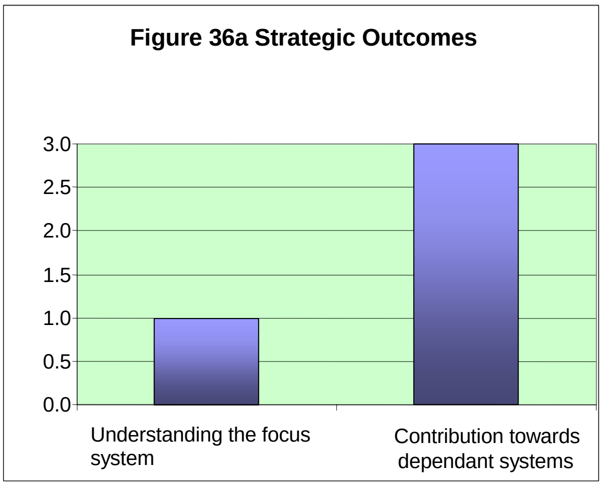
In System Features (Figure 36c) the NRTEE SIS scored high in integrative capacity (3) and project management (3). The SIS has integrated economic and environmental issues at a Federal level and committed resources to ensure a long term program. Significant improvement in adaptive management (score 2) could be pursued with the further development of socio-economic and institutional indicators and the pursuit of further social capital measures. Participation is an area for improvement within the SIS with a score of 2. Criticisms have been levelled at the process for a lack of stakeholder participation and the precedence of political expediency resulting in a lower score (see table 18)(Colman 2002). Participation from a variety of government departments was a feature of the SIS (Table 18).

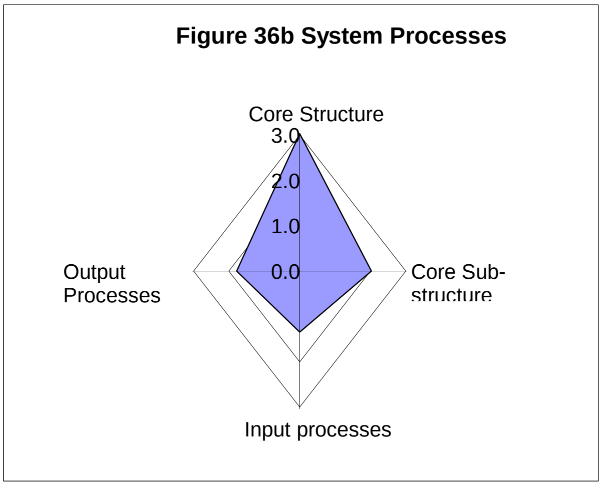
Fisheries Issues has a lower allocated scores for all components (Figure 36d). These scores are based on two outcomes from the SIS around indicators that assess value of commercial stocks (NRTEE 2002b). Therefore the SIS displays a set of average to below average scores in fisheries issues, in line with a generally limited view of the fishery system. The focus of the SIS, as displayed by the chart, is a trend toward target species indicators, recognition of uncertainty, and relationship to management at a national level. These scores are influenced by the fact the SIS maintains a broad national, aggregated approach that focuses on capital issues. However improvements to ecosystem measurements (which are identified in the SIS but require further research), a breakdown to ensure context relevancy, and inclusion of external macro-economic influences would improve the fisheries relevancy in the face of a national approach.

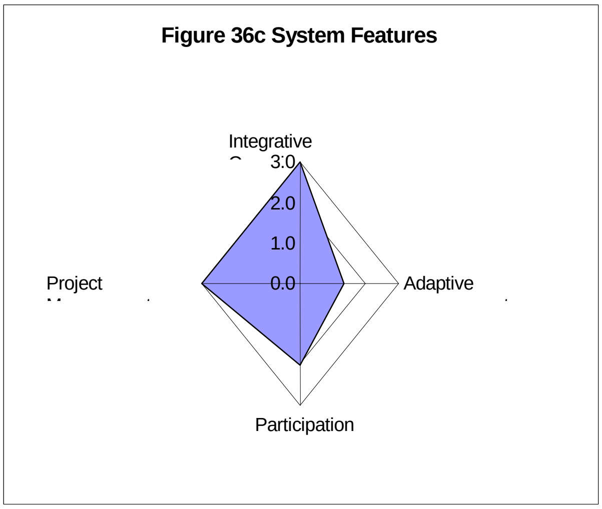
Table 18. Scoring for Case 5

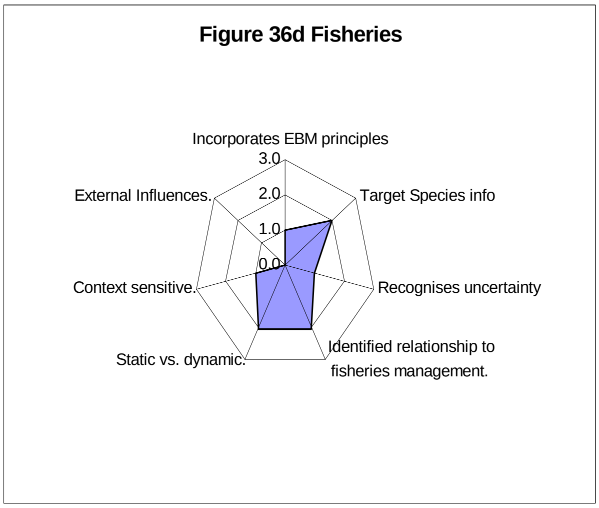
Case 5 NRTEE Environmental and Sustainability Indicator Initiative.				
Strategic Objective	***Sub Objective***	***Operational Objective***	***Score***	***Notes***
1. Strategic				
	Understanding the focus system	*System state and viability*	0	Basic understading of key fishery issues. Use of aggregate and composite indicators.
	Contribution towards other dependant systems	*System contribution to broader societal sustainability.*	1	Integrative approach but fisheries left out of final report. Initial framework comprehensive Fig 35
2. System Processes				
	Core Structure	*Interpretation and definition of sustainability.*	3	Defintiion based on the 'capital' approach, ties in with economic reporting and policy.
		Framework classification.	3	Hierarchical approach based on capital approach. Subdivision of issues to criteria. Fig 35.
		Dimensions of sustainability.	3	SIS uses dimensions of social, human, natural and produced capital for ordering.
		Criteria and sub-criteria.	3	Broad developed criteria based on dimensions. Structures the SIS and sets indicators. Fig 35
	Core Sub-structure	*Objectives*	2	Strategic objectives implicit in SIS. More work on identifying specific indicator objectives.
		Indicators: Scientific	2	Robust measurememnts. Ongoing review process.
		Indicators: Functional	2	Policy relevent. Further development ongoing.
		Performance values	1	threshold levels discussed but not applied in SIS.
	Input processes	*Policy context*	2	Links to core economic policies and decision making.
		Indicator feedback	1	Review of indicators through Cluster Groups. Fisheries indicators left out of final report - future ap.
		Stakeholder / user feedback	1	Poor Stakeholder feedback on fisheries issues. Fisheries not included in final set.
	Output Processes	*Visualisation & presentation.*	1	Minimum use of visualisation. Ongoing development.
		Communication & reporting	2	Regular reporting to stakeholders on indicators and issues.
		Aggregation and scorecards	2	Discussion of aggregation approaches throughout SIS development. Not currently applied.
		Decision making influence	2	indices used to influecne socio-economic decisions. Fisheries not included in final approach.
3. System Features				
	Integrative Capacity	*Interaction of sustainability dimensions.*	3	SIS investigates and assesses the interaction of the capital approach to sustianability.
		Integration with other reporting systems and sectors.	3	Although not fully operational, a focus of the SIS is the integration with national economic systems
	Adaptive management	*Social indicator development.*	1	Minimal use but ongoing development of social indicators within the capital model.
		Institutional indicator develop.	1	Minor recognition of governacne approaches, no set indicators.
		System monitoring and feedback.	2	Formal monitoring. SIS at implementation stage. Extra indicators to be added to SNA.
	Participation	*Participation of stakeholders*	1	Based on expert comittees. Wider consultation required. Criticsm of lack of stakeholder views.
		Participation of decision makers and relevant institutions.	3	Intergovernmental approach through NRTEE.
	Project Management	*Institutional Capacity*	3	Directing resources allocated in budget process.
		Marketing and R&D	3	High profile project. Innovative process in linking economic & environment issues at macro level.
4. Fisheries Issues				
	Incorporates EBM principles.	*SIS reflect broader ecosystem based management principles.*	1	VTE species & habitat extent assessed (Fig 17). Not in final report but possible future addition in SNA.
	Target Species info	*Indicators assess state of the target stock , used in management plans.*	2	Target stock assessment focused on exploitation rate exceedence. (Fig 17) Ongoing devt.
	Recognises precaution	*Assessments explicitly recognise all forms of uncertainty.*	1	Precautionary development approach taken in SIS development. Pilot testing of indicators.
	Identified relationship to fisheries	*Indicators feedback to mgt.*	2	Indicators aim to inform national level policy fisheries mgt strategy.Not in final accounts but in future SNA.
	Static vs. dynamic.	*Static and dynamic reporting within SIS.*	2	A stocks and flows approach is taken. Assessment of states, demands, and linkages of captial.
	Context sensitive.	*Does the SIS take specific fisery context isues into account?*	1	Minimal fishery specific issues in final report. Potential for inclusion in SNA.
	External Influences.	*Informmation on overcapacity, subsidies, trade, fleet structure, IUU fishing and external influences.*	0	No external indicators.

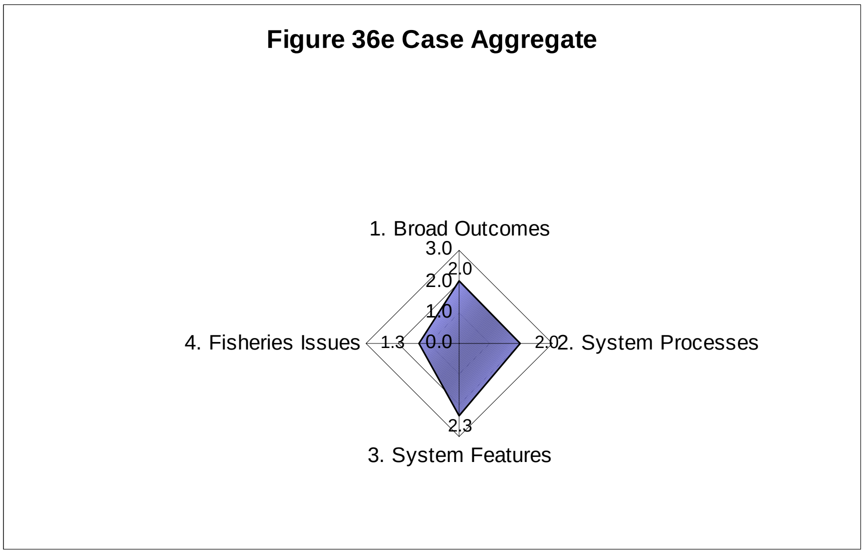
Figure 36(a-e) Orientation graphs Case 5











The case aggregate (Figure 36e) displays an indicator system that has an above average strategic outcome, is strong on structure and sustainability features, but does not explore complex fisheries issues. The NRTEE is an innovative approach that, despite its minimal direct relevance to fisheries management, places the system in a broad, national context along with other natural, produced and human capital. The SIS is in a final stage of development and will provide an important link between fisheries systems and the development of national economic policies, a process that has been generally neglected by other indicator systems to date.

5.7 Case 6. Marine Environmental Quality and Objectives Based Fisheries Management.

5.7.1 Background

Marine Environmental Quality (MEQ) and Objectives-Based Fisheries Management (OBFM) are evolving indicator approaches to assessing the health of marine ecosystems and including sustainability objectives and indicators in fisheries management. MEQ and OBFM are distinct approaches conducted by internal departments within the Department of Fisheries and Oceans (DFO). MEQ assesses the quality or ‘health’ of the marine environment as a part of ecosystem-based management planning, while OBFM is a direct extension of the integrated fisheries management planning process. The two approaches are linked through an evolving approach by DFO to include broader ecosystem considerations into resource planning. MEQ objectives and indictors will be used as a component in integrated management planning under the Oceans Act, and as a basis for assessing ecosystem health in fisheries (Vandermullen 2002). The OBFM approach evolved as a result of emerging ecosystem and precautionary concerns in fisheries. MEQ objectives and indicators are to be directly included into the OBFM process as a part of the move towards ecosystem-based management of marine resources (Arbour et al 2001).

This case study will assess the MEQ and OBFM approaches under the assessment framework. The approaches use similar frameworks and will be increasingly applied together as objectives and indicators are developed. MEQ is defined by (Vandermullen 2002; 38) as:

> *An overall expression of the structure and function of the marine ecosystem taking into account the biological community and natural physiographic, geographic, and climatic factors as well as physical and chemical conditions including those resulting from human activities.*

Under the *Oceans Act*, the Minister for DFO has the authority to develop a national approach on MEQ.[130] The Act calls for the implementation of integrated management plans, the development of a system of national marine protected areas and the establishment of marine environmental quality guidelines, objectives and criteria (Vandermullen 2002). This development is legislated by the Act and given direction by the Oceans Management Strategy (Government of Canada 2002b; Government of Canada 2002c). MEQ is used as a tool to investigate the effectiveness of integrated plans and associated MPAs through the identification and assessment physical and biological ecosystem components and setting objectives, indicators and reference points for long term marine ecosystem preservation (Arbour 2001; Vandermullen & Cobb 2001). MEQ objectives are developed simultaneously with economic and social objectives[131] within the existing federal and international legal framework.

The *Oceans Act* and strategy identify MEQ as an essential component of marine sustainability measures. The MEQ framework links policy and management objectives concerning ecosystem structure and function for an identified marine area to operational programs (indicators and reference points). The framework is designed to establish monitoring programs that evaluate success towards the higher-level objectives in marine ecosystems across Canada. Under the Act it is also possible to establish enforceable regulatory standards for MEQ [132] (Vandermullen & Cobb 2001).

Canadian federal departments have undergone a decade of exploration of MEQ. Initial approaches focused on pollution assessment on Canada's Atlantic, Pacific and Arctic coasts and management of the Great Lakes Systems (Vandermullen & Cobb 2001). Further research on MEQ promoted recognition that MEQ was more than pollution monitoring, and approaches developed to include ecosystem parameters. In the early 1990's DFO and Environment Canada held discussions on MEQ via the Interdepartmental Committee on Oceans. The discussion centred on the broadening of the MEQ approach to include ecosystem management and developing implementation principles and guidelines. (Harding 1992) led a collaborative approach that focused on examining stressors and effects at different scales of organisation, tracking ecosystem processes, and measuring ecosystem attributes. (Wilson 1995) expanded upon these efforts to promote the concept of a national marine status and trends framework

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[130] Section 32 of the Oceans Act Canada (1996) states that the minister may "establish marine environmental quality guidelines, objectives and criteria respecting estuaries, coastal waters, and marine waters."

[131] Vandermullen (2002) notes that the inclusion of social and economic objectives with MEQ objectives is important to place the marine system in context of users and decision-making. The study of MEQ is therefore multi-disciplinary.

based on MEQ attributes. In 1998 DFO established the National Marine Indicator Working Group to focus on the development of fisheries and MEQ indicators (see Case 4: NEIS above). Under the category of marine ecosystems, a set of subcategories was established based on previous experience[133] and indicators were proposed under the S-C-R model (see Case 4). Many of the indicators lacked data to present a national approach, but the NEIS established a developmental framework for directed data gathering on these issues. The most recent evolution for the MEQ program was the development of ecosystem level objectives, with indicators and reference points, and the development of national concepts and terms related to ecosystem based management, at the DFO sponsored workshop in Sidney, British Columbia (Arbour 2001). This workshop explored the notion of ecosystem-based management in detail with national and international collaborations. MEQ was accepted as a basis for ecosystem based management, focusing on the biological, ecological and physical aspects of the system. The framework developed at the conference forms the basis of the operational framework for MEQ under the *Oceans Act* (Vandermullen 2002). This framework will be assessed under the assessment framework.

The development of the OBFM concept complements fisheries management in DFO. Recent developments in the sector have stressed the need for management frameworks that account for ecosystem and precautionary considerations, conservation requirements for species and an improved risk management approach through the use of objectives and indicators (Auditor General 1997). The DFO Strategic Plan outlined the need for objective based management strategies as a part of a wider governmental mandate for addressing sustainability (DFO 2002). The Atlantic Fisheries Policy Review (Government of Canada 2001b) provided a platform to incorporate sustainability assessment mechanisms and species conservation requirements in management plans. Pressure to develop the OBFM approach has also come from external auditing sources. The Auditor General reported on groundfish management in 1997 and shellfish management in 1999, noted the lack of objectives in the management of these fisheries (Auditor General 1997).

The 1997 Auditor General report on Atlantic groundfish stated (Auditor General 1997; 14.8):

> *Although Fisheries and Oceans Canada has stated principles for a fishery of the future, measurable indicators to assess progress are required… A precautionary approach to conservation must be the priority and unsustainable fishing practices need to be*

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[132] Section 52.1 of the Oceans Act provides the authority to develop regulatory standards for MEQ.
[133] Subcategories included contaminants; pathogens, biotoxins and disease; species diversity and size spectrum; primary productivity and nutrients; and instability Vandermullen (1998).

addressed… In addition, performance indicators need to be further developed and planning and performance reporting processes need to be better integrated.

The development of the OBFM approach is a direct response to the Auditor Generals report. In addition a number of problems in the IFMP approach have been identified. Objectives set under the IMFPs were often vague and not measurable, leading to difficulties in the performance assessment of plans (DFO 2002). The roles of science and management were not clearly defined in management plans leading to the duplication of effort and a lack of clarity. In terms of risk assessment, the risks associated with achieving the objectives were not identified nor are mitigating strategies developed to ensure the objectives are not compromised. These issues all contribute to difficultly in assessing sustainability of the fishery. The OBFM approach has been designed to account for these shortcomings in the IFMP process, aiming to set conceptually sound objectives, operational measures, and identify and mitigate risk (Arbour 2001).

OBFM will occur under existing arrangements in the *Fisheries Management Act* and will work in the context of (DFO 2000):

- DFO conservation requirements for species and ecosystems;
- Existing regulatory, policy, and licensing frameworks for fisheries management;
- Existing access and allocation keys in the fishery;
- Emerging oceans management ecosystem policies and plans as they are developed (MEQ and IM approaches).
- Existing stakeholder and advisory committees.

Working within the above parameters, each IMFP will include within its structure:

- Clear and measurable management objectives specific for each fishery.
- Measures respecting aboriginal fisheries and international obligations;
- Measures respecting conservation limits for species and ecosystems;
- Measurable management objectives based on the ecological, biological, social, and economic components;
- Measures to facilitate stakeholder participation, defined roles and increased responsibility;
- A framework to objectively assess performance of the fishery management plan.

5.7.2 Structure and Indicators

MEQ and OBFM frameworks are structured on the basis of a hierarchical unpacking process that establishes conceptual objectives and refines these objectives into operational components that can be measured. The approaches fit the SIS model (identified in Chapter 3) with clear delineation of core and sub structures. While MEQ indicators relate to ecosystem health issues and OBFM relates directly to fisheries management, overall the two approaches are related. MEQ and OBFM will be increasingly linked as the approaches evolve, case studies are implemented, and the indicators and source data are refined (Arbour et al 2001). Both approaches are in final draft stages undergoing road testing through case studies. MEQ has been included in several emerging integrated management plans such as the Western Hudson Bay Ecosystem project (Cobb 2001).

The objective of the MEQ indicator system is (Arbour et al 2001; 14):

> *To identify ecosystem-level objectives, with associated indicators and reference points, which could be used in setting up and implementing management plans for ocean activities and ultimately integrated management plans for ocean areas.*

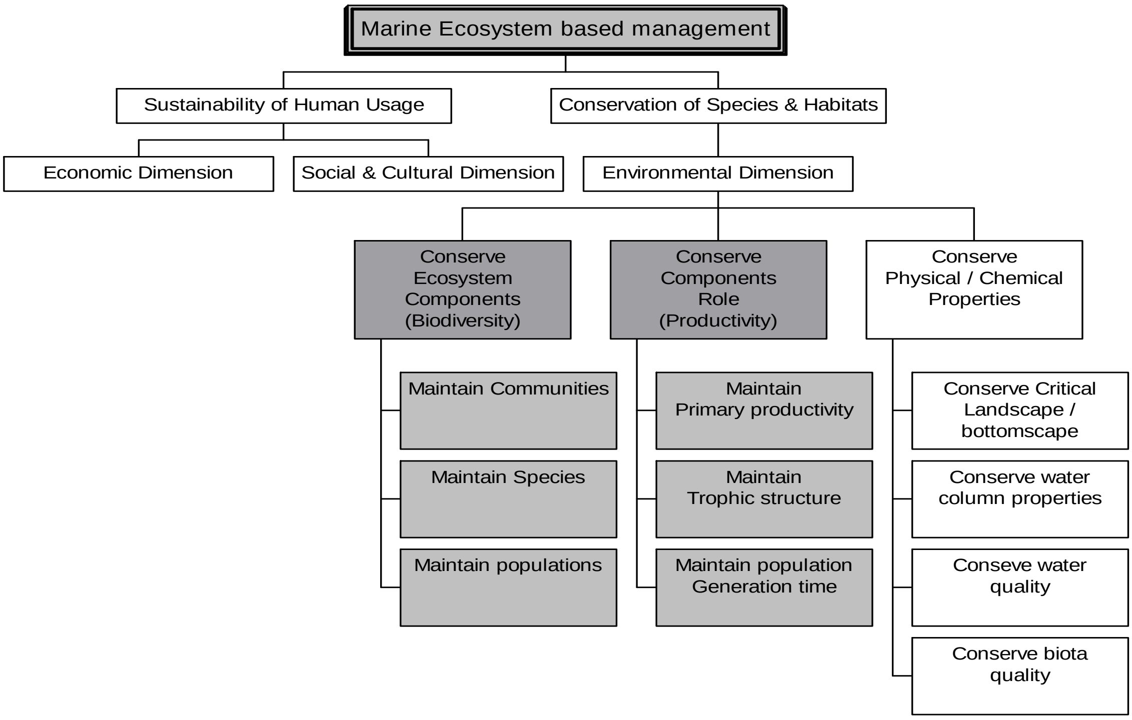
MEQ uses a hierarchical, issues based approach, focusing on ecosystem stressors and effects (Harding 1992) to determine dimensions, criteria and indicators. At the highest level of the framework, two overarching goals for ecosystem management have been identified:

- The sustainability of the human use of environmental resources and;
- The conservation of species and habitats, including those other ecosystem components that may not be utilised by humans (MEQ).

The SIS focuses upon the second dimension: that of the ecological, biological and physical aspects of marine systems. The first objective has been noted as a priority research field, and that social and economic indicators are required to be developed in concert with the biological and ecological indicators. OBFM can be considered an emerging socio-economic account of the human use of fishery resources.

The framework for MEQ is presented below in Figure 37. The environmental dimension is split into the criteria of conserving biodiversity, conserving productivity and conserving physical and chemical properties of the ecosystem. These criteria are unpacked to higher levels of detail, for example, conserving biodiversity is split into maintain communities, species and populations. Each of these criteria is unpacked into characteristics that form the basis of the objectives, indicators and reference points (Vandermullen 2002.) The indicator measures and performance measures are at a developmental stage. The biodiversity and productivity criterion with identified characteristics is listed in Table 18. The full record of criteria, characteristics and developmental indicators and reference points are noted in (Arbour et al 2001).

Figure 37. Framework, dimensions and criteria for MEQ



Adapted from (Arbour et al 2001)

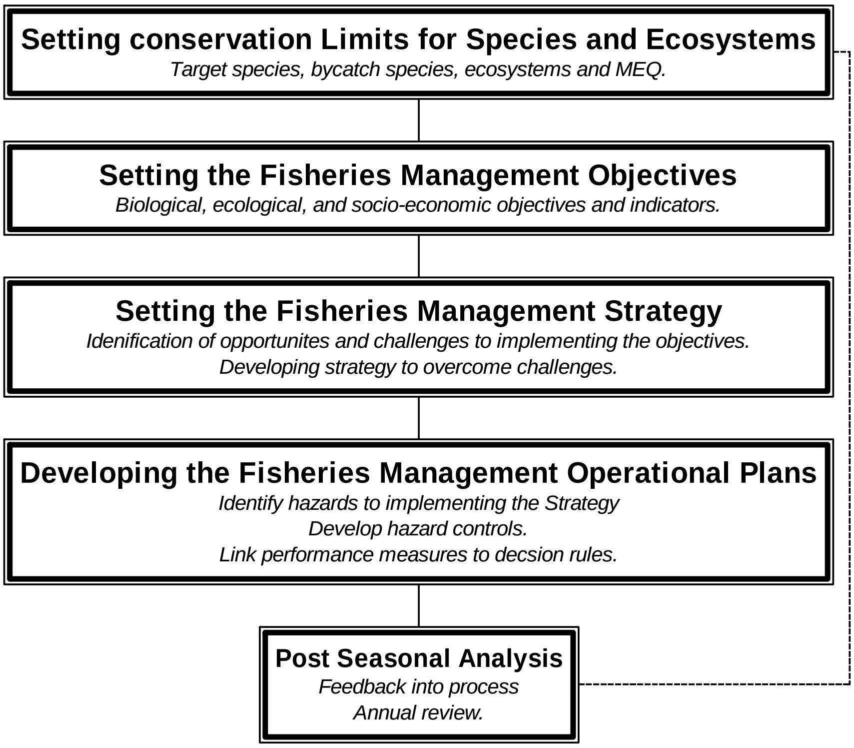
Table 19: Criteria, sub-criteria and characteristics for MEQ

Criteria	**Sub-criteria**	**Characteristics**
Conserve Ecosystem components	Maintain communities	• Trophic level balance • Habitat Complexity • Rare and sensitive habitats • Exotic species
	Maintain Species	• Numbers of species • Species at risk • Ecologically Significant units
	Maintain populations	• Structure Among populations • Structure within populations • Populations at risk • Genetic Diversity among and within populations.
Conserve Productivity	Maintain primary productivity	• Trophic status
	Maintain trophic structure	• Trophic complexity • Habitat availability • Predator prey relationships
	Maintain population generation	• Longevity • Life history strategy • Reproduction • Fishing mortality

Adapted from (Arbour et al 2001)

OBFM is linked to the integrated fisheries management planning process used by DFO to manage commercial stocks, implement conservation measures for species and ecosystems, and establish harvesting and allocation rules amongst users. OBFM is an indicator system that uses a *process driven* framework to establish and organise criteria, objectives, indicators and performance measures as tools in the management of commercial stocks. It is intended to be a part of everyday fisheries management planning and as a result, has a strong management and user focus in the design. OBFM, as described in the background, has a strong emphasis on practical implementation of sustainability with an emphasis on including socio-economic dimensions. The OBFM process framework is detailed below in Figure 38.

Figure 38. The OBFM Process and SIS Framework



Adapted from (DFO 2000).

The OBFM process ensures objectives and indicators are established at the initial stages. Setting conservation limits for species and ecosystems will include reference points that aim to minimise overexploitation, with exceeding the limits establishing a high probability that overexploitation could occur. Setting limits will be the responsibility of technical specialists with the final decision resting with DFO (DFO 2000). The application of MEQ into the OBFM framework would occur through setting conservation limits for species and ecosystems (Arbour et al 2001) (Vandermullen 2002). Each limit will be selected on the basis of each fisheries characteristics. DFO (2000) identifies examples of potential conservation limits in the OBFM approach:

Conservation Limits for Species:

- Biomass limit reference points: spawning stock biomass not to go below a specified limit. If exceeded the probability of poor recruitment increases markedly.
- Fishing mortality reference point. The limit is a mortality rate that if exceeded, stock decline is expected.

Conservation Limits for Ecosystems:

- Biomass limit on prey species that ensures sufficient food for predators.
- Maximum by-catch limit for a species.

On the basis of conservation limits, biological, social and economic objectives and indicators are established that are relevant to the fishery and its harvesting plan (DFO 2000). The result is intended to be a set of conceptual and measurable objectives and indicators that respect the conservation limits and create a foundation for the development of management strategies. The indicators are to be selected through a consultative process[134] including stakeholders directly impacted by the outcome. Socio-economic indicators will relate directly to the fishery under consideration and biological indicators will focus on the target and dependent species and the affected habitat. The process develops a series of conceptual objectives that are progressively refined into measurable indicators. (Cobb 2001) and have identified a series of prototype objectives and indicators that are listed in Table 20 below. The list is by no means exhaustive, but presents an example of indictors that are likely to be used in the OBFM process.

A key aspect of the OBFM approach is the focus upon indicator outputs that include feedback processes, communication strategies, decision rules and management influence. In addition to setting limits, objectives and indicators, OBFM centres strongly on implementation and adaptive management. The indicators are directly linked to a set of influences, hazards and operational decision rules that use the results to set management controls in the fishery.

[134] Ibid. states that through analysis, evaluation, discussion, debate and consensus the advisory committee must identify the fisheries management opportunities and challenges and set clear and measurable fisheries management objectives.

Table 20. Conceptual objectives and indicators in the OBFM approach.

Objectives	Dimension
Maintain adequate spawning biomass to ensure reasonable probability of good recruitment through the full range of conditions.	Biological 1
Manage fishery to minimise bycatch of endangered species.	Biological 2
Leave adequate biomass of forage species for predator feeding opportunity.	Biological 3
Maximise profits in fishing operations.	Socio-economic 1
Stabilise TAC over years.	Socio-economic 2
Manage fishery to increase safety at sea.	Socio-economic 3.
Indicators	**Dimension**
Long term 10- 20 years	
Rebuild SSB above 50,000t (with % certainty) in timeframe.	Bio 1
Bycatch mortality on endangered species <0.01 in timeframe (with % certainty).	Bio 2
Annual Escapement of forage species exceeds 200 000t (% certainty) every year.	Bio 3.
Increase inflation adjusted fish prices by 50% in 15 in timeframe.	SE 1a
Decrease days fishing for constant amount of catch by 20% in timeframe.	SE 1b
Bring harvesting rate to 80% of $F_{0.1}$ within 15 years.	SE 2
Reduce accidents at sea to <2 per 1000 sea-days in time frame.	SE 3
Medium Term 3 – 5 years	
Annual rate of increase in SSB average 10% per year over 5 years	Bio 1
Annual bycatch mortality of endangered species <0.05 within 5 years.	Bio 2
Annual escapement of forage species rebuild to 150 000t within 5 years.	Bio 3
80% of fish landed in top quality grade within 5 years.	SE 1a
Days at sea reduced by 10% within 5 years.	SE 1b
Reduce exploitation rate by 25%, to no greater than 0.2 within 5 years.	SE 2
Reduce accidents at sea by 30% within 5 years.	SE 3
Short term 1 year	
Catches do not exceed level that gives 90% probability of 10% increase in SSB in 2001.	Bio 1
Reduce bycatch of endangered species by 50 individuals in 2001.	Bio 2
Ensure total removals of forage species give at least 90% probability of escapement in 2001.	Bio 3
Have average trip length not exceed 3 days in 2001 and no more than 10% trips longer than 7 days.	SE 1 + 2
Have 100% of retained catch gutted and bled within 90min of landing.	SE 1a
Reduce the number of days that vessels are at sea in gale or storm conditions by 25% in 2001.	SE 2+3

Adapted from (National Policy Committee 2001) and (DFO 2000)

Opportunities and challenges to implementing the indicators are identified and form the basis of a fisheries management strategy . Implementation hazards affecting the strategy are identified and hazard controls are developed with trigger points, monitoring procedures and accountability detailed in the plan. The operational plan attempts to mitigate identified hazards with traditional management tools such as input and output measures and harvesting and compliance controls. In the post seasonal phase performance assessment is undertaken with each step of the process monitored. The steps include (DFO 2000):

- Verifying the hazard controls were implemented as planned;
- Verifying Strategy implemented;
- Verifying Conservation limit respected;
- Assess if Conservation objectives met;
- Feedback into setting objectives and indicators.

The linking of the conservation limits and socio-economic objectives and indicators to the operational plan combines the use of traditional management tools with a focused indicator system. The indicators drive the OBFM process and are the basis of management action through the setting of the fisheries strategy and operational plans. Changes in the indicators will result in action in the fishery through decision rules and trigger points and result in increased accountability and transparency. The SIS aims to identify the environmental and socio-economic influences within the fishery system, and include these influences directly into management.[135]

5.7.3 Status

Both the MEQ and OBFM initiatives are in pilot stages. These indicator systems have undergone extensive review and research within DFO with input from stakeholders and technical specialists. MEQ continues to undergo technical development (Vandermullen 2002) as a tool for independent assessment of marine systems and to monitor the success of integrated management plans and MPAs under the *Oceans Act.* The drive within DFO is now to move the MEQ approach from a conceptual to an implementation phase. Arbour et al (2001) identified a series of next steps to implement MEQ that include:

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[135] (Australian SoE Committee 2001) identifies an example of how the OBFM process is implemented for a hypothetical cod fishery. The conservation objective is to rebuild the spawning stock biomass to 150 000t. The identified threats or forcing on the indicators are from poor recruitment and overexploitation. The strategy to overcome the threats is to set a risk adverse precautionary TAC. Hazards to this strategy exist from misreporting and discarding at sea. A set of hazard controls are presented to mitigate the problem that include observer coverage, dockside monitoring and bycatch analysis. Trigger points are identified as the basis for corrective actions such as reducing the TAC or increasing observers on boats. The example displays the link between the objective, indicator, identification of challenges, the fishery strategy, identifying hazards to the strategy and the operational plan within the OBFM approach.

- Develop objectives and indicators for social, economic and cultural components;
- Refine MEQ objectives, indicators and reference points;
- Regional field studies to apply MEQ and synthesis with IM and OBFM initiatives;
- Establish regional consultative and decision making procedures;
- Establish a formal national working group on ecosystem-based indicators;
- Communication protocols for the latest MEQ developments to stakeholders and users.

The OBFM process is undergoing further internal review through a series of regional pilots (National Policy Committee 2001). Pilot fisheries include Northern Shrimp, 3PS Cod, Inshore scallops, Snow crab, Hudson Bay Narwhal, Pacific Roe Herring and Sablefish. DFO has established a National Steering Committee to implement and monitor the pilots. Further integration with MEQ is a priority and will establish both systems as important developments in incorporating sustainability issues into fisheries management.

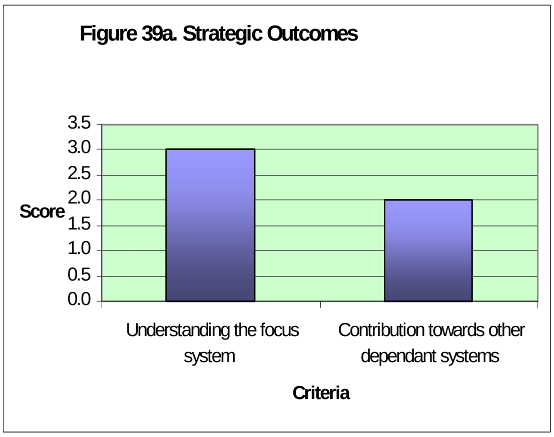
5.7.4 Analysis against the conceptual framework

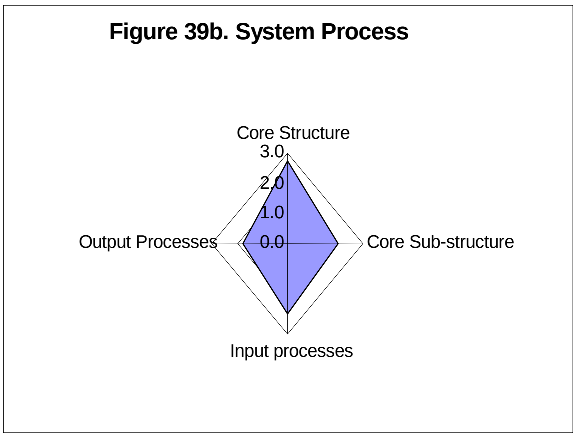
Table 21 and Figure 39(a-e) present scores against the assessment framework. Against Strategic Outcomes (Figure 31a), the MEQ and OBFM approaches score high in understanding the focus system (3) and above average in its contribution to broader societal sustainability (2). MEQ and OBFM, as linked systems, provide a significant detail and clarity about the marine ecosystem and harvesting activities. The SIS facilitates stakeholder understanding, co-management and improved decision making in respect of the focus system. In terms of a broader contribution to sustainability, the approaches are developed within the context of the *Oceans Act*, which aims to integrate management of the marine system. Information from the SIS will be used in cross-sectoral oceans management planning and hence, contribute to dependent systems.

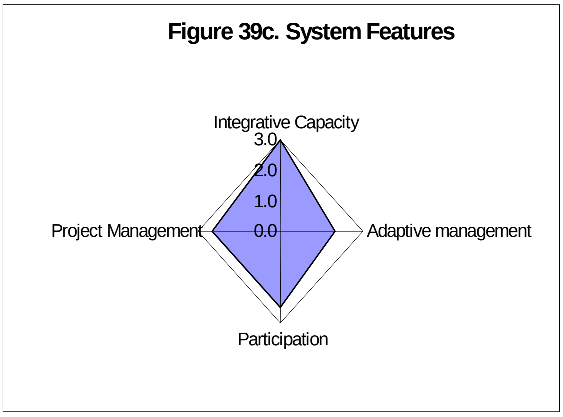
Table 21 Scoring for Case 6

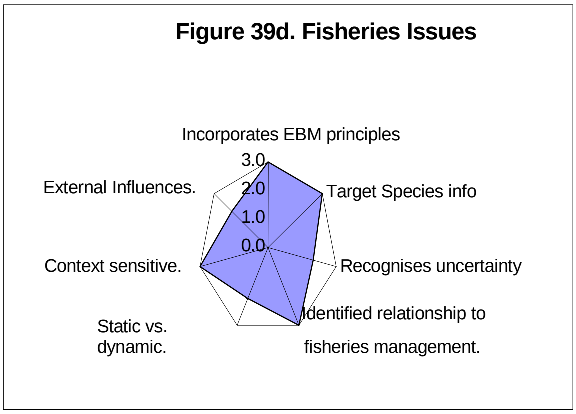
Case 6 MEQ and OBFM Initiatives.				
Strategic Objective	***Sub Objective***	***Operational Objective***	***Score***	***Notes***
1. Strategic				
	Understanding the focus system	*System state and viability*	3	SIS contributes to understanding fishery dynamics & marine environmental quality.Figs 37 & 38.
	Contribution towards other dependant systems	*System contribution to broader societal sustainability.*	2	SIS based on and contributes to Oceans Act and emerging fisheries mgt policies.
2. System Processes				
	Core Structure	*Interpretation and definition of sustainability.*	3	Explicit definition for MEQ. OBFM implied and linked to MEQ and EBM.
		Framework classification.	3	Defined thematic framework (MEQ) and process framework (OBFM) (See Figs 37 & 38)
		Dimensions of sustainability.	3	Multiple dimensions in MEQ and OBFM (biological / ecologcal and socio-economic) Table 19
		Criteria and sub-criteria.	2	Well developed criteria. Ongoing development under dimensions. Table 19 & 20
	Core Sub-structure	*Objectives*	3	Clear objectives related to criteria and indicators. Set basis for indicators in MEQ and OBFM
		Indicators: Scientific	2	Ongoing development of indicators through scientifc consensus. Examples are proxy.
		Indicators: Functional	2	Policy relevant. Ongoing discussion linked with scientific devt. Pilot programs initiated.
		Performance values	1	Developmental stage for reference points.
	Input processes	*Policy context*	3	specific policy context - Oceans management and evolving fisheries mgt policy.
		Indicator feedback	2	Ongoing review process. Documented approach.
		Stakeholder / user feedback	2	Stakeholder consultation in SIS development. Ongoing process.
	Output Processes	*Visualisation & presentation.*	1	Minimal use of visualisation techniques.
		Communication & reporting	2	Ongoing reporting of review and pilot projects. No formal mechanisms.
		Aggregation and scorecards	1	Aggregation discussed, research ongoing.
		Decision making influence	3	relevant to decision making in fisheries management.Linked to integrated fisheries mgt planning.
3. System Features				
	Integrative Capacity	*Interaction of sustainability dimensions.*	3	Recognises and the complex and intelinked nature of the fishery system.
		Integration with other reporting systems and sectors.	3	Links to Oceans Act and across sectors in IM. Will apply to fishery sector via DFO.
	Adaptive management	*Social indicator development.*	2	Recognation and attempts at social indicators.
		Institutional indicator develop.	1	Minimal use of governance in SIS.
		System monitoring and feedback	3	Formal review process in SIS. Post harvest review.
	Participation	*Participation of stakeholders*	2	Stakeholders consulted, ongoing process.
		Participation of decision makers and relevant institutions.	3	Formal involvement of government organisations and interal departments.
	Project Management	*Institutional Capacity*	3	Dedicated funding and capacity. Steering commtee estbalished.
		Marketing and R&D	2	SIS image is perceived as useful if not well understood.
4. Fisheries Issues				
	Incorporates Ecosystem Mgt Principles	*SIS reflect broader ecosystem based management principles.*	3	Strong focus on EBM component, taget and associated species and ecosystems.Table 19.
	Target Species info	*Indicators assess state of the target stock, used in management plans.*	3	Target species indicators developed under DFO fisheries mgt. Inclusion into OBFM. Table 20
	Recognises precaution	*Assessments explicitly recognise all forms of uncertainty.*	2	Uncertainty explicitly recognised.
	Identified relationship to fisheries	*Indicators feedback to mgt.*	3	Direct feedback fishery mangement planning. SIS will be the basis of management strategy. Fig 38
	Static vs. dynamic.	*Static and dynamic reporting within SIS.*	2	MEQ investigates the dynamic nature of the ecosystems.
	Context sensitive.	*Does the SIS take specific fisery context isues into account?*	3	Highly context relative. Operates at the fishery unit scale. Aggregation to regional unit proposed.
	External Influences.	*Information on overcapacity, subsidies, trade, fleet structure, IUU fishing and external influences.*	2	External issues identifed and proposed for SIS. Developmental.

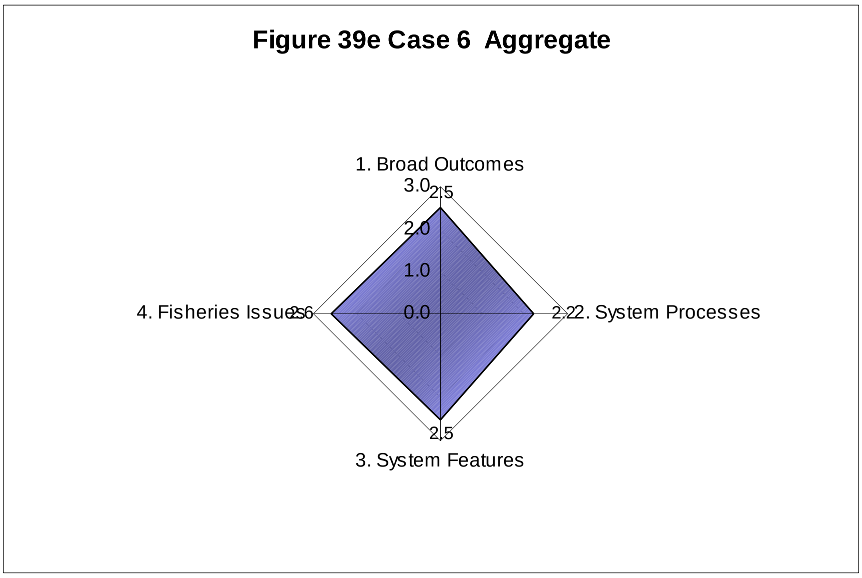
Figure 39 (a-e) Orientation graphs for Case 6











In Figure 39b, MEQ and OBFM display a high score in core structure (2.8), an above average score in sub-structure (2), a high score in inputs (2.3) and a slightly below average score in outputs (1.8). MEQ and OBFM display overarching definitions that set the frameworks (thematic and process based) and filter down to dimensions, criteria and sub criteria that structure the development of indicators. MEQ structures relate primarily to ecosystem structure and function while the OBFM approach focuses on fisheries management, target, associated and dependent species, and socio-economic issues. In the sub-structure both systems show advanced development in the identification of objectives (Table 21). Indicators and performance values for these systems are in developmental stages with ongoing input from stakeholders. Proxy indicators have been identified in the SIS that ground ongoing research and enable pilot testing. The high input score relates directly to the direction provided by Canadian marine policy, primarily the Oceans Act that establishes the basis for MEQ and integrated management. Further improvements to output processes are envisaged as the MEQ and OBFM approaches mature and are applied to real cases. Investigation and application of visualisation techniques to present the data, reporting protocols, and aggregation will improve the SIS. The systems maintain high decision-making influence with the results of the SIS fed directly into fisheries management and planning (Table 21).

For System Features (Figure 39c), the MEQ and OBFM approaches score an overall high rating that displays a commitment to the features and attributes of sustainability research. The SIS shows a high integrative capacity (score of 3) with recognition and measurement of the complex ecological and socio-economic components within the fishery, cross-reporting in the fisheries sector, and planning between sectors within the Oceans Act. The focus on integrated management is a key driving influence in the development of the MEQ and OBFM. Adaptive management, participation and project management all obtain high scores (2.3, 2.5, 2.5). The OBFM approach is developing socio-economic and institutional indicators, while both systems engage in monitoring, participation of stakeholders and decision makers, and maintain institutional capacity and marketing of the SIS.

The key strength of the MEQ and OBFM approach is the recognition and assessment of Fisheries Issues (Figure 39d). There is a specific attempt at the inclusion of ecosystem-based management principles and criteria (3), target species assessments (3), direct feedback to fisheries management planning (3), and context sensitive indicators that operate at the fishery scale (3). In addition, above average scores are obtained for the incorporation of precautionary approaches in the SIS (through explicit recognition and development of quantitative measures), a dynamic approach to reporting, and the inclusion of external influences (developmental process). Improvements to the average scores will result in an SIS that maintains a strong focus on fisheries management outcomes and relevance to decision making.

The Case Aggregate (Figure 39e) displays a well-balanced system that scores highly in all component areas. The linked MEQ and OBFM approach, on the basis of the mean of the component scores, obtains an overall result of 2.5 for Strategic outcomes, 2.2 for System Processes, 2.5 for System Features, and 2.6 for Fisheries Issues. The SIS, despite being in a developmental stage of application, can be considered a model approach for reporting on and incorporating sustainability concerns into management.

5.8 Case 7. The Traffic Light Method

The Traffic Light Approach (TLA) was developed by Caddy (1998) as a method to incorporate precautionary management approaches and decision rules into fisheries management. The DFO Maritimes region, through the Regional Advisory Process and Fisheries Management Studies Working Group (FMSWG), initiated an investigation of the TLA in 1999. The TLA is used as a part of stock assessment, broadening the approach to include ecosystem and precautionary parameters. The key appeal of the TLA is a means of visualisation of indicator data as a series of traffic lights. TLA is used in Maritimes fisheries management, and has culminated in a series of focus meetings to develop the approach into a useable tool through the application of case studies, development of a workbook, and research into the use and improvement of the method and consensus over its application. The system has enjoyed a measure of support from stakeholders and users, and has been identified as a potential framework that could be used to present the MEQ and complement the OBFM approach described in Case 6 above.

5.8.1 Background

Caddy developed the traffic light approach as a framework to include precautionary measures into data poor fisheries (Caddy 1998; Caddy 1999). The use of the TLA revolved around a system of red, yellow and green lights to categorise multiple indicators in relation to defined target and limit reference points.[136] For each indicator a colour was allocated depending on the score (good, medium or bad) and based on reference points. Decision rules (the outputs from the

[136] Target reference points define a condition that is considered desirable to achieve. A limit reference point defines an unacceptable outcome.

SIS) were linked to the TLA, with specific management actions taken depending on the number of lights recorded, and becoming more restrictive with increasing amounts of red lights. The basic TLA can be summarised as follows (Halliday et al 2001):

- Uses a multiplicity of indicators of system status;
- Classifies the current state of indicators in relation to reference points using a system of green, yellow and red lights;
- Establishes the management response rules associated with the numbers of lights of each category.

The precautionary approach has evolved as a core component of the sustainable management of fisheries (Garcia 1994; FAO 1995). Canada has passed domestic legislation to implement the precautionary approach with the *Oceans Act 1997* promoting “the wide application of the precautionary approach to the conservation, management, and exploitation of marine resources in order to protect these resources and preserve the marine environment” (Government of Canada 1996). In terms of fisheries management, the IFMP and the OBFM processes have evolved to include sustainability and precautionary-based criteria. The emergence of the Traffic Light approach complements the OBFM approach as a tool to aid selection, research, monitoring and visualisation of fisheries indicators. A discussion paper on the regional application of the precautionary approach was developed by DFO and defined the characteristics of a management system that includes precautionary components (RAP 2000):

- Objectives are set;
- Strategies to achieve them are implemented;
- Unacceptable outcomes are defined (limit reference points);
- Uncertainty is taken into account;
- System performance is monitored through indicators;
- There is pre-agreement on the corrective actions to be taken if limits are approached.

The TLA provides a framework within which these needs can be addressed. Although the method was initially designed for data poor fisheries, (Halliday et al 2001) notes that the method can be adapted for data rich situations. For data poor situations the TLA requires that management advice is formulated in a transparent objective manner and that gaps in information can be targeted. In data rich situations, the focus is on the biology of the resource and ecosystem interactions of the fishery. The TLA has its basis in stock assessment and broader ecosystem influences, but future development will include the incorporation of socio-economic information relevant to the fishery and linked from the OBFM indicator system (Arbour et al 2001; Halliday 2001).

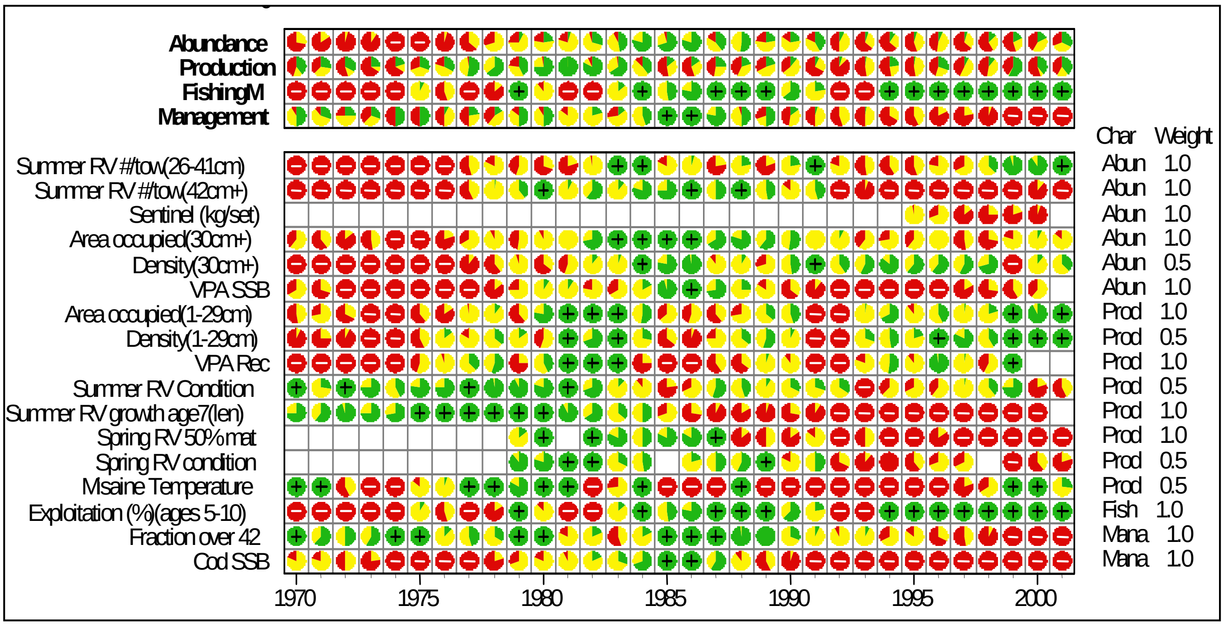
The TLA presents a means to include non-traditional fishery information in the management system. Indigenous and fishermen's information can be directly included in the analysis and can become a part of the management process (Halliday et al 2001). The presentation of the indicators as traffic lights is a visually pleasing process that increases communication and understanding amongst users, and has already achieved limited success in this regard.

5.8.2 Structure and Indicators

(Halliday et al 2001) distinguishes the Traffic Light Method (TLM) from the earlier Traffic Light approach. The TLM has taken the system developed by (Caddy 1998) and adapted it to suit stock assessment requirements for Maritimes fisheries. TLM is an analytical approach that brings together data from a range of sources and examines system behaviour across a suite of indicators. It is an innovative approach to using monitoring results, results from stock assessment, anecdotal observations, governance, and socio-economic considerations in management decisions (Koeller et al 2000). At this point in time the TLM examines the biological and ecosystem components of a fishery, focusing specifically on the target stock considerations. Arbour et al (2001) and Halliday et al (2001) note that the method is being expanded to include data not included in traditional modelling approaches but necessary for sustainability. The TLM with its capacity to include a range of indicators broadens the scope of stock assessment within a transparent framework.

The framework for the TLM is displayed below in Figure 40. This framework employs an approach consistent with the assessment framework detailed in the methodology. Two significant features highlight the TLM structure: the organisation and selection of the indicators under key fisheries dimensions and the means of visualisation (or outputs) of indicator data through the use of coloured signals or traffic lights. The framework displayed in Figure 40 is an application of the TLM to a groundfish fishery (Haddock 4VW). The method is used in different formats for different fisheries, but the overall concept and visualisation remains constant.

Figure 40. Traffic Light table for Atlantic Haddock 4VW, 2001 (Fanning 2002).



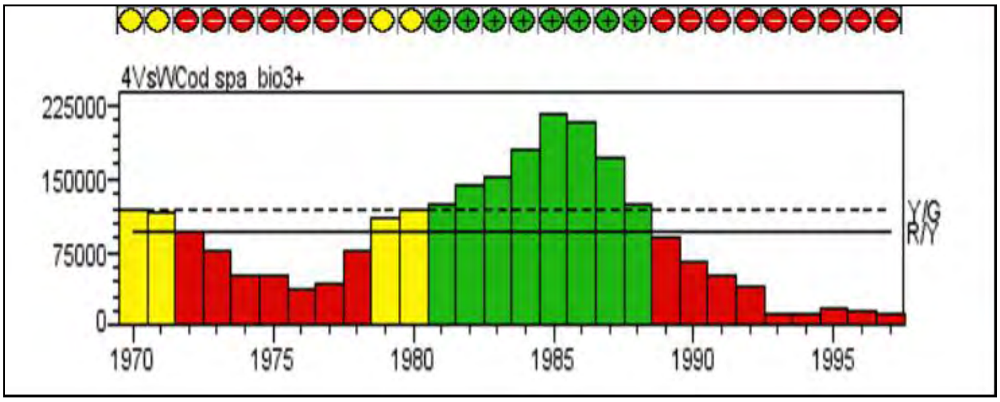
The TLM model above establishes indicators relating to the target population, mortality and management. (Halliday et al 2001) identifies that this approach will evolve to include indicators of ecosystem, socio-economic and regulatory compliance. Indicators are based and selected on identified fishery *attributes*, a conceptual property of the stock (or fishery) that describes its status (Halliday et al 2001).[137] Each indicator undergoes a process of peer review and validation. (RAP 2001) identifies an indicator template that forms the basis of the peer review and validation process. The template gives the theoretical and practical evidence for the relationship of the indicator to the attribute it measures, delineation of reference points, recommendations on aggregation, and details on properties such as estimation, sensitivity, and interpretability. The peer review process as displayed in (RAP 2001) results in a library of indicators that can be applied to the TLM framework.

Each indicator is allocated a traffic light colour according to its performance against a set reference points. The establishment of reference points is hence an important step in this process as it determines the colour and influences the resulting decision rule or management action.

[137] For example, fishery or stock attributes include biomass, growth rate, and mortality. Socio-economic attributes include employment, revenues and catch value etc. Indicators are direct quantitative measurements that describe the attributes. Attributes (described as criteria in the methodology and framework) describe specific elements of the dimensions of sustainability (ecological, social, economic etc). The terms are interchangeable. In Figure 40 the attributes are aggregated to form the abundance, production, fishing mortality and management scores.

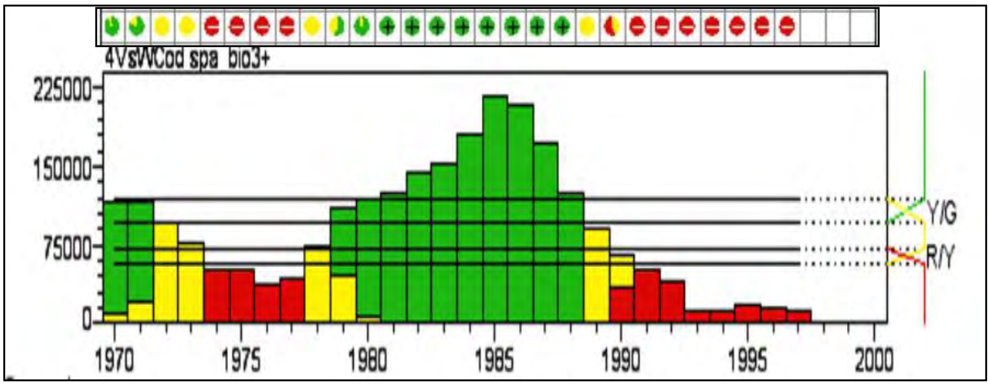
Figure 41 below displays the process for selecting strict colours based on the reference points for biomass of the 4VsW Cod fishery.

Figure 41. Selection of traffic light colours according to a target and limit reference point (Fanning 2002).



A score below the solid line of 90 000 tonnes, the limit reference point, results in a red light. A result between the limit and target (dashed) lines, between approximately 90 000 and 120 000 tonnes, results in a yellow light application, a signal that implies proximity to unacceptable conditions. Above the target point, over 120 000 tonnes signals a green light and satisfactory conditions. A significant problem identified by Halliday et al (2001) was the loss of information of an indicator when converted to a strict traffic light. Once within a strict green, yellow or red light, there is no discrimination to where the result lies within its range. In addition, the sharp transition between the colour ranges (that is from red to yellow, or yellow to green) presents the problem that very small changes in an indicator can lead to problems of interpretation when close to a boundary. For example, if a score lies within the green zone and close to the yellow boundary, a slight change can place it within the entire yellow zone and lead to a different management decision. To get around this problem (Halliday et al 2001) incorporated a 'fuzzy logic approach' that introduces gradual changes between the boundaries and retains more information than the strict light approach. The allocation of lights includes a 'transition zone' where a score consists of fractions of the neighbouring colours and gives more information on the indicator status. This is detailed in Figure 42 below.

Figure 42. The selection of traffic light colours according to target and limit points with a Fuzzy Logic approach (Fanning 2002).

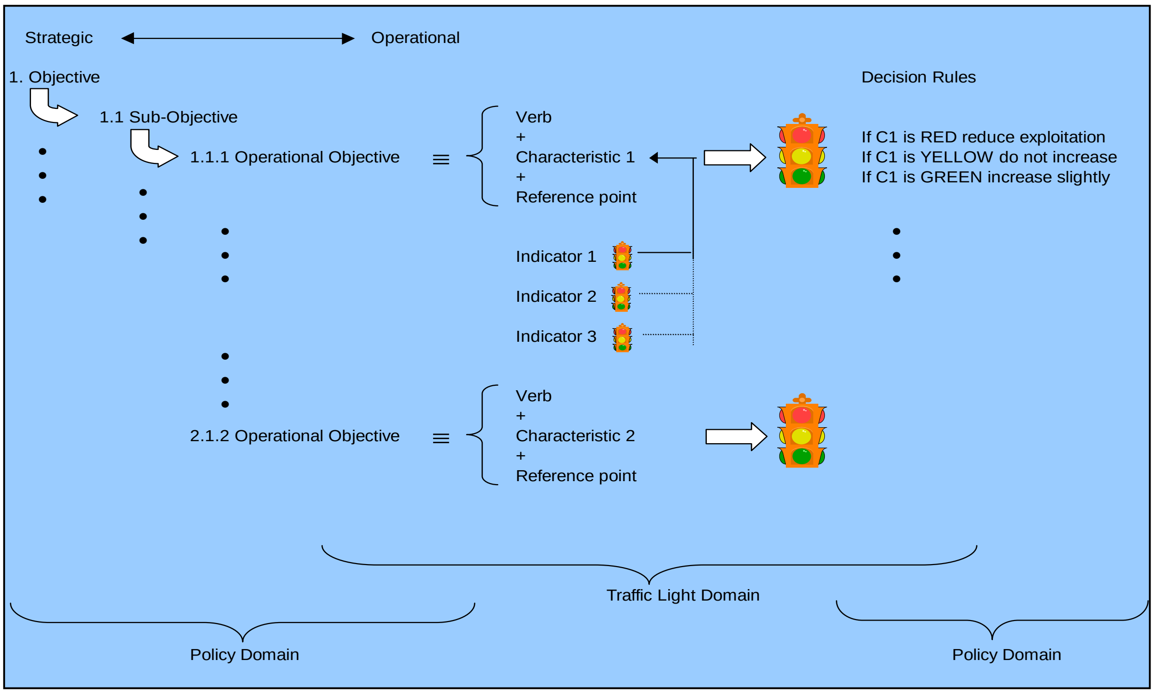


Indicators are aggregated by scaling (or normalising the scores) and applying a function that summarises the scores from several indicators. On the basis of these calculations a traffic light result is obtained for several aggregated indicators (see Figure 40). Weighting is also considered for indicators in aggregation, though the level of weighting and the process is an issue of debate (Halliday et al 2001). The aggregated attributes provide summary of the dynamics of the fishery system and emphasise specific aspects of the resource. The TLM at this stage of development organises aggregate indicators into four characteristics for assessment of the fishery. They include (Halliday 2001; RAP 2001):

- Abundance
- Production
- Fishing Mortality
- Ecosystem / Environment.

As the TLM is developed and a range of indicators are validated, new characteristics under social and economic dimensions will be added to the system. Characteristics can be further aggregated to an overall index. At each stage of the process, from data to indicators, indicators to characteristics and a final index, integration involves setting a traffic light colour that provides information about the status of the indicator. This process results in a net loss of information but increases understanding and transparency in decision making. An important consideration is that individual indicator series are still available for decisions that need further analysis than the aggregate scores. The focus of the TLM is that of simplicity and communicability amongst the managers and stakeholders in the fishery and leads to improved debate and decision-making. The application of the TLM within a broader policy framework is detailed in Figure 43 below.

Figure 43. The TLM nested within a broader policy approach (Fanning 2002).



The unpacking of strategic objectives into sub-objectives and operational objectives occurs within the 'policy domain' through consultative processes. This process of subdivision, common in indicator frameworks as a means to link strategic elements to practical measurable indicators, links the policy domain with the TLM. Objectives for fisheries will be set through the OBFM and MEQ process.[138] The TLM then serves as a tool to validate, plan and visualise the indicators and present the outputs of the system to users. Operational objectives consist of a verb, characteristic and reference point. For example, a common objective in the fishery may be to conserve stock biomass. This would translate to an operational objective of maintain (*verb*) biomass (*characteristic*) at 1990 levels (*reference point*). Once the characteristic has been identified, a number of attributes and indicators can be measured and assigned lights according to the reference points (see the TLM table above) and aggregated to form the characteristic

[138] The OBFM and MEQ indicator systems are described above in Case 6. These systems use unpacking processes to identify and organise dimensions, strategic objectives and operational objectives for Canadian fisheries.

score. On the basis of the lights assigned to aggregated characteristics, decisions rules can be constructed to manage the fishery. (Koeller et al 2000) notes that the TLM should be linked to TACs or harvest control rules based on stock dynamics to create an integrated management framework.

Halliday et al (2001) and Fanning (2002) observe that decision rules are beginning to be addressed in fisheries management systems based on TLM results. Formulating appropriate rules for management on the basis of the TLM remains a significant challenge, and requires practical application of the approach in management planning and consensus amongst stakeholders in the appropriate forums (such as the Fisheries Resources Conservation Council). Despite formal decision rules being at a developmental stage, TLM approach is emerging as a tool for advice, management planing and harvest allocations for several fisheries in Atlantic Canada (Koeller et al 2000; Fanning 2002).

5.8.3 Status

TLM is emerging as a tool to broaden the scope of management under a transparent, peer reviewed and precautionary framework. The system has undergone rigorous development within DFO Maritimes with application to several key stocks. Currently the TLM has been applied to Atlantic shrimp stocks (Koeller et al 2000), and selected groundfish stocks including cod, white hake, and flounder (DFO 2001; RAP 2001; Fanning 2002). The method has been adopted by the Northwest Atlantic Fisheries Organisation (NAFO) for the assessment of data poor stocks (Koeller et al 2000). In addition, the TLM has been investigated as a means to visually represent indicators under the *Oceans Act* MEQ program (Arbour et al 2001).

The Traffic Light Method continues to evolve and take into consideration new indicators and characteristics related to ecological, socio-economic and governance considerations and develop procedures for formal decision rules based on its outputs. Its emerging use across Atlantic fisheries and potentially MEQ initiatives signals an emerging consensus on the ability of TLM to incorporate sustainability considerations into fisheries management.

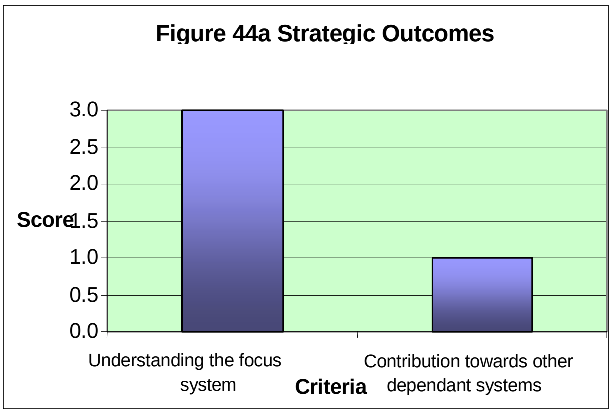
5.8.4 Analysis against the assessment framework

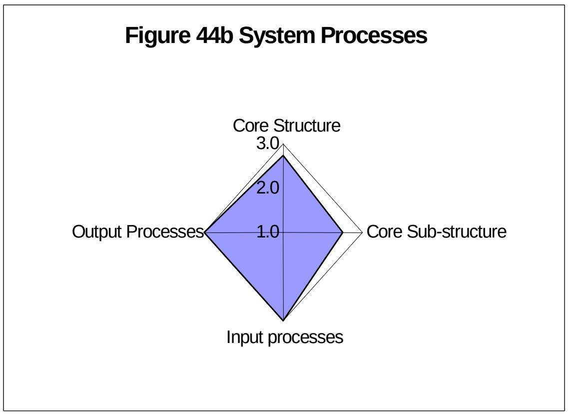
The results against the assessment framework are displayed in Table 22 and Figure 44(a-e).

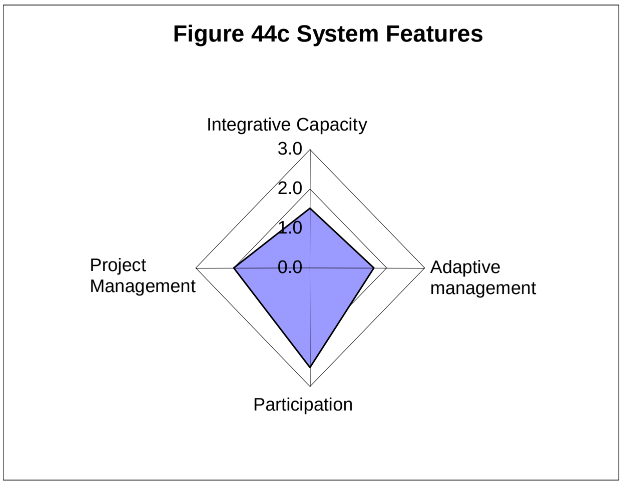
Table 22. Scoring for Case 7.

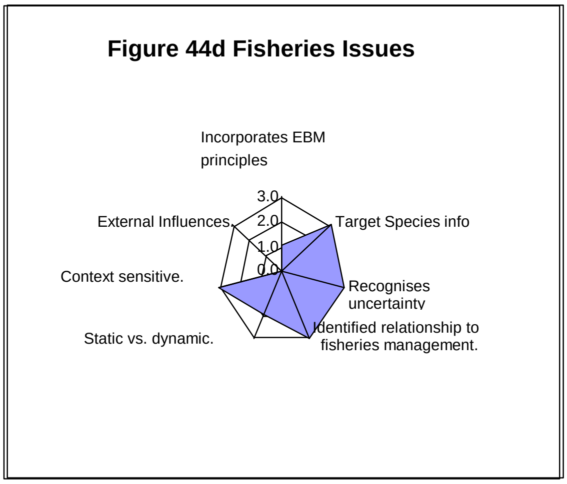
Case 7 The Traffic Light Method.				
Strategic Objective	**Sub Objective**	**Operational Objective**	**Score**	**Notes**
1. Strategic				
	Understanding the focus system	*System state and viability*	3	TLM offers detailed insight into the biological and ecological aspects of the system.
	Contribution towards other dependant systems	*System contribution to broader societal sustainability.*	1	Single issue focus, increasing broader application into ecosystem based approaches.
2. System Processes				
	Core Structure	*Interpretation and definition of sustainability.*	2	Defintiion implied in the structure of the SIS (maintenance of the target dimensions).
		Framework classification.	3	Adanced framework based on biological aspect, precautionary approach and visualisation.Fig 43
		Dimensions of sustainability.	3	Specific dimensions based on target species considerations. Evolving an EBM approach.
		Criteria and sub-criteria.	3	Dimensoins split into criteria for the basis of indicators. Termed attributes.
	Core Sub-structure	*Objectives*	2	Objectives relate to the OBFM process. Set for the particular fishery being assessed.
		Indicators: Scientific	3	Clear, robust, measurable, researched indicators.
		Indicators: Functional	2	Policy relevant but further work required to be used in decision making.
		Performance values	3	Reference points established for each indicator.
	Input processes	*Policy context*	3	Defined policy context. SIS used in planing and decision making in fisheries sector.
		Indicator feedback	3	Testing and review. Indicator used in SIS after detailed review process by Fisheries Mgt Comittee.
		Stakeholder / user feedback	3	Extensive feedback through consultation process. Model accepted by users.
	Output Processes	*Visualisation & presentation.*	3	Clear, effective, innovative visualisation of data. Core focus of SIS. Figure 40 & 41.
		Communication & reporting	3	Effective communication of results of SIS.SIS has been used as decision tool Fig 40
		Aggregation and scorecards	3	Established aggregation method. Use of fuzzy sets and colour coding to aggregate indicators.
		Decision making influence	3	SIS used as basis for consensus decision making in Maritimes fisheries.Ongoing devt.
3. System Features				
	Integrative Capacity	*Interaction of sustainability dimensions.*	1	Interactive nature recognised. No tools for assessment. Single dimension focus.
		Integration with other reporting systems and sectors.	2	SIS feeds into sector reporting in Maritimes fisheries. Intent to export to other systems e.g. MEQ.
	Adaptive management	*Social indicator development.*	1	Recognition but no use.
		Institutional indicator develop.	1	Recognition but no use.
		System monitoring and feedback.	3	Established monitoring and feedback process through Fisheries Mgt committee.
	Participation	*Participation of stakeholders*	3	Full participation of stakeholders, especially industry in using the SIS.
		Participation of decision makers and relevant institutions.	2	Strong single institution focus, developing links.
	Project Management	*Institutional Capacity*	2	Adequate resources.
		Marketing and R&D	2	Emerging recognition of SIS approach. Export to national and iternational fora.
4. Fisheries Issues				
	Incorporates Ecosystem Mgt Principles	*SIS reflect broader ecosystem based management principles.*	1	Focused on target species approach. Some environment indicators, proxy stage. Ongoing.
	Target Species info	*Indicators assess state of the target stock , used in management plans.*	3	Strong target focus. Excellent approach to managing target resources.
	Recognises precaution	*Assessments explicitly recognise all forms of uncertainty.*	3	Uncertainty taken into account in process and indicators through reference points.Fig 41 & 42
	Identified relationship to fisheries	*Indicators feedback to mgt.*	3	Direct management relationship. SIS used in decion making.
	Static vs. dynamic.	*Static and dynamic reporting within SIS.*	2	Emerging dynamic approach, linked to regular stock assessment.
	Context sensitive.	*Does the SIS take fishery specific context isues into account?*	3	SIS context specific. The ecological fishery system is the basis.
	External Influences.	*Information on overcapacity, subsidies, trade, fleet structure, IUU fishing and external influences.*	0	No recogntion of external fisheries issues.

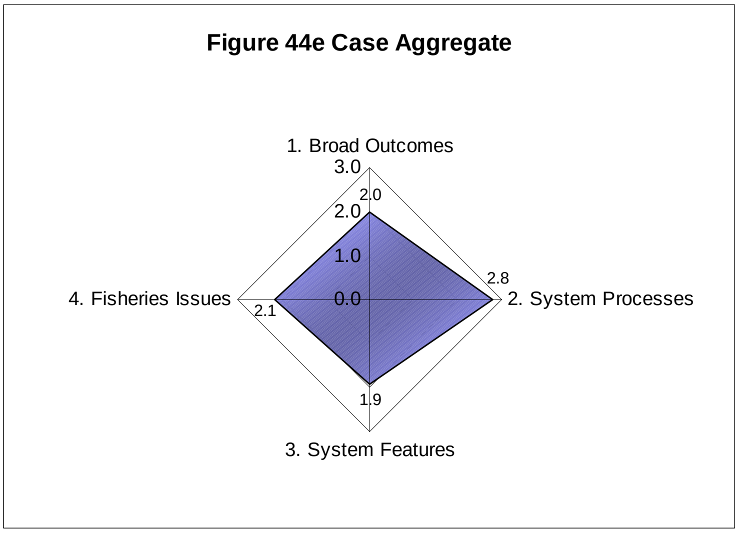
Figure 44(a-e) Orientation graphs for Case 7











Against the Strategic Outcomes (Figure 44a) the SIS scores high for understanding the focus system (3) and low for contribution towards the contribution to broader societal sustainability and dependent systems (1). The TLM is focused (at this stage of development) on the biological aspects of the target species, with reference to ecosystem and management considerations. Improved ecosystem and management dimensions are expected to be incorporated in the model in future developments. The focus system high score results in a simplified and effective visualisation, and hence understanding, of the fishery dynamics. The TLM is a specific regional SIS at this point in time and contributes to the fisheries management of the DFO Maritimes region (reflected in the low score). However, with future development the approach is likely to be exported to other indicator and reporting systems such as the MEQ approach and account for broader socio-economic issues.

A strong System Process (Figure 44b) is evident with high scores in core structure (2.8), sub-structure (2.5), inputs (3) and outputs (3). This is evidenced by a strong definition, framework based on biological / ecological attributes, specific dimensions based on the target species characteristics, and specific criteria that form the indicators. The indicators are scientifically robust and are designed to inform decision makers. An advantage of the TLM is the establishment of specific performance measures and reference points for each indicator, which set the appropriate traffic light signal. For input considerations the TLM is based on a defined policy context of establishing methods to include precautionary concerns into management. Extensive review and testing of the indicators feeds back into the SIS. The highlight of the TLM is the output process that scored the maximum result for each operational component (Table 21). The core of the TLM is the visualisation methodology based on traffic light signals, which delivers clear, precise and effective visualisation of data and facilitates reporting and communication. The method has an established procedure to aggregate up the scales and is used as a tool for achieving consensus in fisheries decision-making.

In terms of System Features (Figure 44c) the SIS has a noticeable trend towards project management (2) and participation (2.5) and below average scores in integrative capacity (1.5) and adaptive management (1.7). In terms of project management the TLM has adequate resources and marketing, with an emerging recognition of the utility of the SIS in other sectors. Participation in the development and application of the SIS has been encouraged by decision makers and fisheries managers, and stakeholders have reacted positively to the SIS being used as a tool in management planning, particularly in the management of northern shrimp stocks (Koeller et al 2000). To improve the SIS in regards to system features an expansion from the single dimension focus of the target species is necessary. In addition increased development of socio-economic and institutional indicators (and linked to the OBFM process) will increase the effectiveness of the SIS.

The focus of the SIS against the Fisheries Issues component (Figure 44d) is skewed towards the assessment of target species (3), recognition of uncertainty (3), context sensitivity and relationship to fisheries management (3). An average score (2) is obtained for generating dynamic stock reporting approach as the SIS is emerging as a dynamic management tool. The SIS obtains minimal scores in ecosystem-based management and external issues in the SIS. The low scores relate to the structure and purpose of the TLM, as it is currently used as a tool for incorporating precautionary concerns into target species management. As the SIS evolves, the scores in these areas would be expected to increase with further investigations into broader dimensions, criteria and indicators. The issue is recognised within the SIS and several proxy measures have been suggested (hence the score of 1.0 for the EBM component). Furthermore, integration with the OBFM approach will increase this score.

The Chart Aggregate (Figure 44e) reveals an overall above average score for all components with a higher aggregate for the System Processes (2.8). This highlights the emphasis that the TLM places on the structure of the SIS and the scientific basis for the core structure, sub-structure, input and output processes. The TLM focuses upon a visualisation technique to present indicator information to decision makers and stakeholders and is a working example of the benefits that can arise in management when a robust method of visualisation is used to interpret and present indicator data.

5.9 Conclusion

Canadian jurisdictions have developed a diverse set of initiatives relating to reporting on sustainability in fisheries. In particular, two categories have been identified: broad national reporting approaches that address a cross section of issues (Case 4:NEIS and Case 5:NRTEE); and fisheries specific initiatives that relate to management practices and stakeholders (Case 6: MEQ/OBFM and Case 7: TLM). The National Environmental Indicator scheme developed thinking around national environmental reporting through the use of indicators, including the notion of ecosystem health. This system was superseded by the National Roundtable on Environment and Economy, which aims to present a core set of aggregated measures on par with popular economic measures such as the GDP. This SIS has achieved political recognition and support, and despite the lack of final fisheries measures and has advanced the debate and application of indicators at a national level. However the system did not adequately address fisheries issues in the final report but flagged the possibility of an extension of the System of National Accounts. In comparison to the broadscale initiatives, the Marine Environmental Quality / Objectives Based Fisheries Management approach delivers a specific framework to assess and measure marine quality and fisheries issues beyond the target stock. Despite being in a developmental phase, the initiative places emphasis on developing strategic and operational objectives and indicators to assess and guide fisheries development in the marine ecosystem. The Traffic light approach presents an innovative way to use indicators in a fisheries management context, highlighting the effectiveness of an indicator system when visualisation and communication strategies are considered.

All of the above cases have evolved in relative jurisdictional isolation, but with future developments (especially in indicator measures) systems are expected to move closer in operation and in sharing data. This will be particularly significant for the MEQ / OBFM and TLM initiatives, with potential links in visualisation and data being explored. Further testing and application of the fisheries specific information could potentially lead to improvements in the fisheries component of the NRTEE approach – a significant improvement over current efforts. However, substantial information and political commitment is still required to make the NRTEE, MEQ/OBFM and TLM fully operational and accepted as valid tools in management practice Anecdotal evidence from the case studies suggests that the Canadian initiatives are moving in this direction.

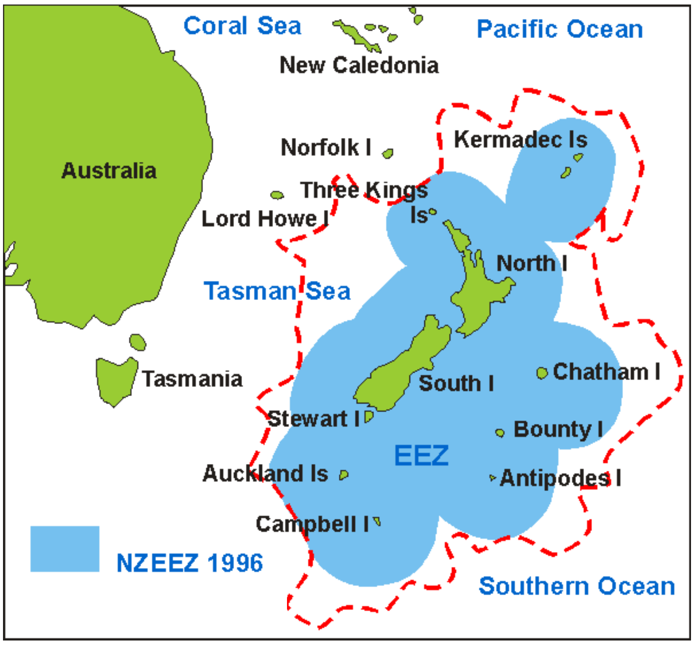
Chapter 6: National Approaches Case Study: New Zealand

6.1 Introduction

New Zealand's fisheries are a valuable source of social, cultural and economic well-being. Fisheries comprise a source of significant export earnings and employment, a source of domestic supply and a focus for indigenous culture. Maori (New Zealand's indigenous population) have strong cultural ties with fisheries, and these are recognized in domestic common law and legislation.

The New Zealand EEZ covers an area of 5 million square kilometres (Figure 45). Over 1,000 species of marine fish are known to live in New Zealand waters, of these approximately 100 are harvested in commercial fisheries (Statistics New Zealand 2002a). Despite the range of the EEZ, there is relatively little continental shelf, and much of the area is not biologically productive (Gilbert 2000). Seventy-two percent of the zone has waters of over 1 000 m deep, 22% is between 200 and 1 000 m and only 6% is less than 200 m deep (FAO 1999b).

Figure 45. The New Zealand Exclusive Economic Zone (SeaFic 2002)



The dashed line displays the potential claimable continental shelf zone.

New Zealand fisheries cover the inshore finfish, shellfish and rock lobster fisheries, mid and deep-water fisheries, and the rapidly growing aquaculture industry (Statistics New Zealand 2002a). Commercial catch and aquaculture production is around 650,000 tonnes a year (SeaFic 2002). Almost 80% of this harvest is mid and deep-water fish, 12% is pelagic species, and approximately 10% is inshore finfish, crustaceans and shellfish (SeaFic 2002; Statistics New Zealand 2002a). The main species in terms of value are: hoki, orange roughy, greenshell mussels, spiny red rock lobster, paua (abalone), snapper, ling, and squid (SeaFic 2002).

Seafood represents New Zealand’s fourth largest export earner (SeaFic 2002). Exports in 2000 were worth $1.43 billion, behind dairy, meat and forestry. Domestic sales are estimated to be $130 million (Statistics New Zealand 2002a). The top five export species for the industry in 1997 were hoki (NZ$ 133 million), rock lobster (NZ$ 111 million), greenshell mussels (NZ$ 86 million), squid (NZ$ 72 million) and ling (NZ$ 51 million). The main export markets for New Zealand seafood are Japan, the United States and Australia with ongoing expansion to Asian and European markets.

Hoki remains the most significant New Zealand fishery in tonnage and export earnings. The fishery was developed in the early 1970s by Soviet and Japanese vessels with catches peaking at 100 000 t in 1977 (Ministry of Fisheries 2002a). When the New Zealand EEZ was declared in 1978, catch dropped to 20 000 tonnes with the displacement of foreign fleets. Over the years, with increasing domestic interest and ability, the catch of hoki has increased ranging from 175 000 t in 1988-89 to 215 000 t in 1995-96 (Ministry of Fisheries 2002a). The total catch for 1997-98 was estimated to be the highest ever at 269 000 t (Statistics New Zealand 2002a). In the 2000-01 fishing year the TAC was set at 250 000 t.

Employment in the seafood industry stood at 10,173 full-time equivalent jobs in 1998 (FAO 1999B). Over the last six years, employment in the industry has risen by 14 percent, with jobs in the processing sector increasing by 41 percent (SeaFic 2002). This is a result of increasing catch by domestic vessels and commitment to value-added processing. The industry also employs significant numbers of seasonal workers (Statistics New Zealand 2002a).

Aquaculture is one of the fastest growing areas of the New Zealand seafood industry. Production has risen exponentially over the past decade and further increases are predicted before 2010 (Statistics New Zealand 2002a). Greenshell mussels, salmon and Pacific oysters continue to be the mainstay of New Zealand's aquaculture industry. In 2000 the aquaculture industry produced $210 million worth of products (Statistics New Zealand 2002a)

6.2 The Policy Framework for Sustainable Development in New Zealand.

The last 10 years has seen significant changes in the way the sustainability is interpreted and applied in New Zealand domestic policy and legislation.[139] Prior to the 1990s, New Zealand's approach to environmental management was piecemeal and incremental (Ministry for the Environment 1997). International and domestic developments have resulted in a number of policy changes that apply sustainability principles to the actions of government departments, including independent review. These mechanisms are detailed below to give an overview of how the concept of sustainability is applied in the New Zealand context.

New Zealand has a variety of legislation that relates to sustainable development. At the national level, key bodies for implementation include the Ministry of the Environment, Department of Conservation, Ministry of Foreign Affairs, Ministry of Fisheries and Ministry of Agriculture and Forestry. The Parliamentary Commissioner for the Environment holds a significant independent auditing role (detailed below). Reforms have concentrated on establishing a sustainable management and ecosystem based framework, and implementing international obligations such as *Convention of Biological Diversity* and *Agenda 21* (Weeber 1998). The difficulties inherent in the management of multiple ecosystems, variety of users and delivering coordinated, transparent decision making at all levels of government provide challenges for sustainability implementation in New Zealand. However, the trend is moving in the direction of integrated approaches as policy and legislative tools focus to achieve these outcomes (Government of New Zealand 2002).

The most important development is the *Resource Management Act 1991* (RMA): the principal legal framework for sustainable development in New Zealand. The RMA is considered the primary coordinating legislation for environmental management (Weeber 1998; Ministry for the Environment 2002b). The Act focuses upon the management of natural resources, the coastal environment, noise, subdivision, and land use planning and sustainable development (Ministry for the Environment 2002b). The Act interprets sustainability and promotes the sustainable management of natural and physical resources (Ministry for the Environment 1995).

This is set out in the Act (Ministry for the Environment 2002b) as:

(The purpose of the RMA) is to promote the sustainable management of natural and physical resources. In this Act, 'sustainable management' means managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well-being and for their health and safety while:

(a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations;
(b) Safeguarding the life-supporting capacity of air, water, soil and ecosystems; and
(c) Avoiding, remedying, or mitigating any adverse effects of activities on the environment.

The development of the RMA was a significant shift away from the complex and uncoordinated approaches to environmental management that had characterised decades past practice. The RMA replaced 50 different sets of environmental laws and regulations (including 20 major statutes) and replaced legislation relating to air, water, noise and coastal management (Ministry for the Environment 2002b). The RMA takes an increasingly holistic approach to management that moves away from traditional zoning management to an outcome / effects based approach. This approach essentially assesses the suitability (or the effects) of a proposed activity in a particular region under the principles of the Act and in the context of regional environmental issues (Ministry for the Environment 2002a). The RMA delivers decision-making authority through a hierarchy of regional and district councils under the premise that local authorities are the most affected by and engage environmental issues (Ministry for the Environment 2002d). New Zealand has 12 regional areas that are divided into 70 district or city councils (Ministry for the Environment 2002b) Each region is required to prepare a regional policy statement and regional plans under the Act with the Ministry for the Environment and central government establishing standards and national guidelines (Ministry for the Environment 2002c). Policies and plans are structured in a hierarchy within the RMA form the national policy level to regional and district plans. Significant resources have been allocated by the New Zealand government to implement the RMA (Ministry for the Environment 2002d)

In addition to the RMA, a range of legislation has been enacted to implement sustainability in New Zealand. While not exhaustive, the list below highlights significant regulations that involve resource management, conservation and sustainability issues (Ministry for the Environment 1995; Weeber 1998):

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[139] A detailed account of the reforms and issues in New Zealand's environmental management history is provided in the 1997 SoE Report Ministry for the Environment (1997).

- ***The Treaty of Waitangi***. Provides the basis from which Maori (indigenous) interests are expressed and can be resolved;[140]

- ***Environment Act 1986.*** Established the Parliamentary Commissioner for the Environment;

- ***Conservation Act 1987.*** Enabling legislation for the management of national parks and lands;

- ***Forests Amendment Act 1993***. Focuses on the sustainable management of indigenous forest land to provide a full range of products and amenities in perpetuity, while retaining the forests natural values;

- ***Biosecurity Act 1993***. Relates to the management of pests and unwanted organisms;

- ***Fisheries Act 1996***. Relates to the use, conservation, enhancement, and development of fisheries resources (see below);

- ***Hazardous Substances and New Organisms Act 1996***. Manages hazardous substances and establishes an Environmental Risk Management Authority (ERMA) to assess the introduction of hazardous substances or new organisms into New Zealand;

- ***Ozone Layer Protection Act 1996***. Sets up a framework to facilitate compliance with changes to obligations under the Montreal Protocol.

This legislation provides the regulatory framework for the implementation of sustainable development in New Zealand. In addition, the Government has developed a number of strategies that contribute its achievement. A significant milestone was the development of the Environment 2010 Strategy (Ministry for the Environment 1995). The strategy was the first comprehensive statement of environmental priorities by a New Zealand government and complements a national economic policy previously released[141]. It contains a long-term vision for the New Zealand environment, principles for integrating environment, society and the economy, and goals and an action agenda focusing on priority environmental issues (Ministry for the Environment 1995).

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[140] The treaty was signed in 1840 between Maori tribes and the British Crown. It establishes the Waitangi Tribunal for the resolution of indigenous claims. The Minister of Maori Affairs is required to report to Parliament on an annual basis on progress made by the Government on implementation of Waitangi Tribunal recommendations. The current government policy is that all major claims under the Treaty of Waitangi made by Maori will be resolved by the turn of the century (United Nation Commission for Sustainable Development 2002).

[141]Ministry for the Environment (1997) describes that the government released *Path to 2010* in 1993 and *New Opportunities* in 1996 as components of a broad national economic policy. Environment 2010 was a released as a part of the government reform process.

The agenda set out in Environment 2010 details the goals, risks and actions for a number of key environmental issues. The policy also highlights the parameters of an environmental management agenda, focusing upon integrated decision making, policy tools and information management (Ministry for the Environment 1995). In order to coordinate action a monitoring and assessment program was necessary to identify priorities and implement the objectives of the policy (Ministry for the Environment 1997). The development of indicator systems within New Zealand has evolved as a direct response to this need and the integrated management concept espoused within the policy.

Environment 2010 set an important strategic framework and direction for the environmental component of sustainable development across New Zealand. However with a change of government in 1999 the policy was superseded by a number of subsidiary strategies based on issue areas such as the Oceans Policy and Biodiversity Strategy[142] [Environment. 2002 #398]. *Environment 2010* remained an important shift in the national approach to implementing sustainability and was influential in developing integrated and ecosystem-based approaches in natural resource sectors such as fisheries.

The Parliamentary Commissioner for the Environment (PCE) was established under the *Environment Act 1986* (Parliamentary Commissioner for the Environment 2002a). The role of the commissioner is to conduct independent reviews of government policies and programs in relation to sustainable development. The PCE aims to assess and improve the policy process within Parliament, local councils, business, communities and civil society (Parliamentary Commissioner for the Environment 2002b). The PCE recently launched an assessment of the implementation of sustainability by the New Zealand government between the Rio Earth Summit in 1992 and the Johannesburg Summit in 2002 (Parliamentary Commissioner for the Environment 2002a,b). A key recommendation was continual engagement, by government, industry and civil society, in the development of a sustainable development vision and framework, and an implementation, monitoring and review strategy (Parliamentary Commissioner for the Environment 2002b). This directly relates to the development of sustainability indicators across New Zealand as tools to implement and monitor progress.

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[142] (Parliamentary Commissioner for the Environment 2002b) details the variety of environmental strategies released after the Environment 2010 policy. They include the Oceans Policy, New Zealand Biodiversity Strategy, NZ Coastal Policy Statement, National Energy Conservation Strategy, Fisheries Environmental Management Strategy, Hazardous Waste Strategy, Transport Strategy and Climate Change Strategy. It should be noted that with *Environment 2010* considered 'not active', New Zealand does not have an overarching environmental policy direction for whole of government.

New Zealand's *State of the Environment Repor*t in 1997 and the *National Environmental Indicators Programme* represent the first attempt by New Zealand to gather and coordinate information on the environment and sustainability (Parliamentary Commissioner for the Environment 2002a). The SoE 1997 report provided an insight into the diversity and overlapping jurisdiction of regulations and responsibility for environmental management. It provided a platform for the investigation of an indicator program with the recognition that information was spread across government jurisdictions (Ministry for the Environment 1997). The Environmental Performance Indicators program provides the basis for ongoing monitoring and assessment of a variety of issues and forms the basis of the case study below.

6.3 Management of Fisheries and the Marine Environment in New Zealand

New Zealand has an extensive maritime area and important maritime activities such as fishing, oil and gas, tourism and indigenous interests that contribute to socio-economic wellbeing (Statistics New Zealand 2002b). Under the RMA 1991, the management of land, inland water, air and coastal resources has come under integrating legislation, but the marine sector remains generally uncoordinated (Weeber 1998). Legislation and policy in the marine sector lacked a common objective or an ecosystem focus (Ward 1998). In response to these issues, international commitments and increasing recognition of the value of an ecosystem-based approach, New Zealand engaged in the development of an Oceans Policy in 2000.

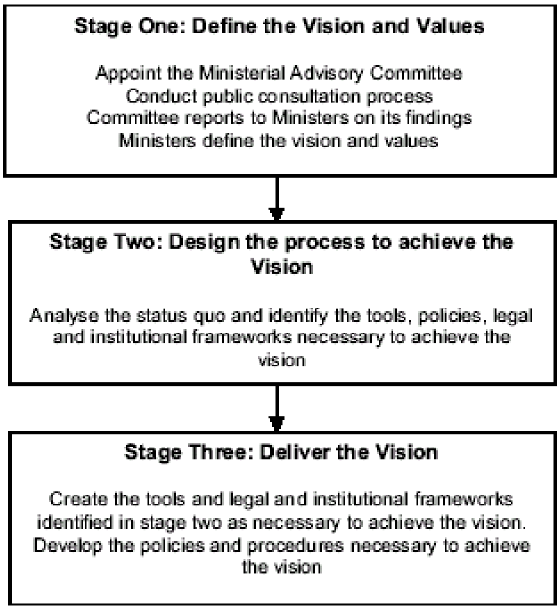
The Oceans Policy aims to developed a coordinated, ecosystem-based, inclusive and transparent approach to marine management. It aims to identify a cross section of values and uses of the ocean by the public. The policy aims to (Ministerial Group on Oceans Policy 2001):

- Identify New Zealanders' vision for their coasts, beaches and ocean;
- Provide ways to manage the impact of human activity on the marine environment;
- Address the interaction between land management and the status and quality of the marine environment and the inter-tidal zone;
- Consider management and policy issues associated with such areas;
- Provide ways to reconcile competing interests and conflicting goals in respect of management of the marine environment.

The Department of Prime Minister and Cabinet oversee the development of the Oceans Policy, with assistance from an appointed Ministerial Advisory Committee (Ministerial Group on

Oceans Policy 2001). The development of the policy is split into three stages, displayed in figure 46 below.

Figure 46. The stages of the New Zealand Oceans Policy



(Adapted from Ministerial Group on Oceans Policy 2001)

Stage 1 has been completed with the agreement on a vision for the policy after a public and stakeholder consultation. The vision states (Ministerial Group on Oceans Policy 2001; 3):

> *Healthy Oceans: New Zealanders understand marine life and marine processes and, accordingly take responsibility for wisely managing the health of the ocean and its contribution to the present and future social, cultural, environmental and economic well-being of New Zealand.*

Crucial to the development of the policy was identification of a set of core policy issues that faced coordinated oceans management and would need to be addressed to achieve the vision. (Ministerial Group on Oceans Policy 2001) and (Department of the Environment, 2002) identify the core issues as:

- Holistic management;
- Treaty of Waitangi;
- Compliance and enforcement;
- Models for integrated management;
- Decision making models;
- Information management;
- Monitoring and measurement.

The core issues focus on the requirement of an integrated, ecosystem approach with supporting information, monitoring and decision tools. At the time of writing, the Oceans Policy has reached stage 2 with the development of a work plan and methodology to 2003 [Environment, 2002 #399]. A cornerstone of stage 2 involves the generation of a public discussion paper and draft oceans policy developed on the basis of the core issues. The format and structure of the policy is yet to be established, including the legislative and policy approach that facilitates the integration of different marine sectors, regulations, and decision-making frameworks. Hence the Oceans Policy is still at a formative level in New Zealand.

The Ministry of Fisheries (MoF) is the agency responsible for the management of fisheries resources in New Zealand. The minister is responsible for setting annual quota on commercial stocks and administering a range of legislation and statutory responsibilities. Legislation includes (FAO 1999b):

- *Fisheries Act 1996*
- *Fisheries Act 1983*
- *Maori Fisheries Act 1989*
- *Treaty of Waitangi (Fisheries Claims) Settlement Act 1992*
- *Marine Farming Act 1971*
- *Seafood Industry Board Act 1963*
- *Ministry of Agriculture and Fisheries (Restructuring) Act 1995.*

The *Changing Course* report (Ministry of Fisheries 1996) indicated a change in the philosophy of management in New Zealand. It introduced sustainability principles and ecosystem-based management into the sector, and advocated an economically efficient, healthy and long-term industry. The development of the *Fisheries Act 1996* provided the legislative basis for this shift. The Act provides for the sustainable use of fisheries resources and recognises New Zealand's international obligations relating to fishing. The major features of the Act include (FAO 1999b; Ministry of Fisheries 2001f):

- The adoption of an ecosystem-based approach;
- A clear enunciation of the precautionary approach;
- Greater stakeholder involvement in decision-making through open consultation;
- Coordination with other statutes controlling the incidental deaths of protected species such as sea birds and marine mammals;

- Consolidation of the quota management system as the primary means of controlling fishing; and
- Giving effect to indigenous fishing rights as provided for in the Treaty of Waitangi (Fisheries Claims) Settlement Act 1992.

The Act introduced significant changes for management. Implementation of the new act has been a primary activity for the Ministry of Fisheries over the last five years with the introduction of changes to registry services, reporting requirements, permits, and enforcement and compliance activities.[143] However, the key challenge has been the transition from target resource to ecosystem-based management and its implementation within fisheries management systems.

The core objective of the *Fisheries Act 1996* is to provide for the utilisation of fisheries resources while ensuring their sustainability (Ministry of Fisheries 2001f). Utilisation includes conservation, development and enhancement while sustainability refers to maintaining the productivity of resources at a level to support the maximum sustainable yield and mitigating the effects on the broader ecosystem (Gilbert 2000). The legislation specifies in that all decision-makers must take an ecosystem approach to management, expressed in the Act by the following principles:

- Associated or dependent species should be maintained above a level that ensures their long-term viability;
- Biological diversity of the aquatic environment should be maintained;
- Habitat of particular significance for fisheries management should be protected.

In addition, the Act states that decision makers must take into account the best available information in management, uncertainty within that information, and act with caution when making decisions.[144] It states that “The absence of, or any uncertainty in, any information should not be used as a reason for postponing or failing to take any measure to achieve the purpose of this Act” (Government of New Zealand 1996) - a direct reference to the Precautionary Principle.

The management of fisheries under the Act is a blend of input controls (effort and gear restrictions) and a strict quota management system (Connor 1999; FAO 1999b). Under Act setting a Total Allowable Catch (TAC) and a Total Allowable Commercial Catch (TACC)

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[143] Refer to Ministry of Fisheires (2001) for a review of the significant changes to fishing activities and management.
[144] Section 2, Part 10 of the Act.

controls the annual catch from a stock (Gilbert 2000). The TACC is subdivided into Individual Transferable Quotas (ITQs) that are tradable rights to harvest a portion of the stock annually. Under the Act, the TAC must 'maintain the stock at or above the level that can produce MSY.' (Gilbert 2000). A focus of the recent Act was to provide a mechanism to bring all commercial fish species into the quota management system (OECD 1997b; FAO 1999b).

Each year, the Minister sets a number of sustainability measures for all QMS fisheries. This includes the setting of Total Allowable Catch for each stock in the system and allocation of the TAC to stakeholders in the fishery via ITQs (Ministry of Fisheries 2001e). The decisions are tabled in parliament and announced with other regulatory controls.[145] There are 45 species or species groups and 272 fish stocks currently in the QMS (Misitry of the Environment 2002a). More species are to be added over the next three years. Quota is allocated in perpetuity and is fully transferable apart from a range of quota aggregation restrictions - holders must be New Zealand residents or companies that are less than 25 per cent foreign owned (Connor 1999). A range of input controls also applies to QMS species. For example, minimum legal sizes, closed seasons and areas, gear and method restrictions are used in the management of the stock (OECD 1997b). These controls are used to complement TAC and establish a variety of tools that can be used to manage stocks (Ministry of Fisheries 2001e). For stocks that lie outside the QMS, management focuses on the use of permits and regulations. At present a moratorium on the issue of new permits is in place for non – QMS species (FAO 1999b). This aims to control effort in the fishery while the transition to QMS takes place.

New Zealand has established a complex output based process for the management of target species through the setting of TACs and ITQs. The management of target species however is one component of managing fisheries for sustainability. With emerging pressures arising from commitments such as the *Fisheries Act 1996,* the *Biodiversity Strategy 2000* and the *RMA 1991,* there is a drive to establish mechanisms that deal with impacts of fisheries upon non-target species and marine habitats, marine protected areas, impacts upon protected species, pollution issues and pest control (De Fontaubert 1998). As a means to coordinate Ministry activities in line with legislative requirements and to progress best practice in fisheries management, the Ministry is preparing an *Environmental Management Strategy* (Ward 2001). The strategy focuses on the implementation of sustainability and ecosystem management objectives into Ministry activities. It will link in closely with other relevant policies, such as the Oceans Policy and Environmental

[145] See the report Ministry of Fisheries (2001) for a detailed example of sustainability measures and regulations.

Performance Indicators, and will form an important mechanism for delivering action on ecosystem-based impacts.

The strategy outlines a vision and approach by which the Ministry of Fisheries will align and improve its processes to meet fisheries-related environmental obligations (Ward 2001). While still in the early stages of development, the strategy proposes a set of decision tools to achieve an ecosystem-based approach. Legislation will not be changed in the short term, but amendments could be applied in the future. (Ward 2001) notes that the strategy should be based on outcome-oriented objectives, indicators, decision criteria, targets, monitoring systems and performance assessment. Several features of an environmental management strategy have been identified in a scoping report by Ward (2001). Suggested reforms include:

- An Environmental Management Advisory Group for each managed fishery;
- Comparative Ecological Risk Assessment for use in fisheries assessments;
- An annual 'State of the Fisheries Report' that reports on progress towards achieving environmental targets for each fishery;
- Directed science support building on existing strengths in fisheries science and building capacity in 'integration science'- particularly risk assessment, ecosystem modelling and decision making tools;
- Linking the EMS with traditional management approaches such as stock assessment and sustainability measures by the Minister.

As a means to operationalise ecosystem objectives, improve policy coordination and implement co-management, the Ministry of Fisheries has initiated the development of Fisheries Management Plans (FMP). The FMP is legislated under the Fishery Act 1996 that aims to construct a flexible, user driven, and integrated approach to the management (Ministry of Fisheries 2001a, Ministry of Fisheries 2001b). FMPs establish a framework for setting multiple objectives in the fishery (such as managing the target stock and reducing impacts upon non-target species) and setting action plans to achieve these objectives. Where the *Environmental Management Strategy* presents an overall policy direction and strategic objectives for New Zealand Fisheries, the FMP delivers an implementation and monitoring procedure that is adapted to each particular fishery (Ministry of Fisheries 2001a, Ministry of Fisheries 2001b).

Fisheries management has undergone significant reform in since the introduction of the *Fisheries Management Act 1996*. In particular, management is dealing with a transition from single species stock management to ecosystem-based management. The later is not intended to replace the former, but rather complement and broaden the base of management to take account of significant influences in fishery systems. The transition includes the development of practical; fishery level approaches and indicators that can be monitored.

6.4 Sustainability Indicator Systems in the New Zealand Fisheries Sector.

The development of indicator systems for New Zealand fisheries heralds a change in management philosophy towards sustainable and co-managed approaches. The demand for information and management systems that can orientate fisheries towards sustainability has resulted in the development of the Environmental Performance Indicators (EPI) program.

The EPI model aligns with two key requirements for sustainable fisheries: information and action. The 1997 SoE report (Ministry for the Environment 1997) highlighted the critical issue of uncoordinated and sparse environmental information for use in decision making in New Zealand. The EPI program has been established as a direct response for the need of ongoing, timely and accurate information on activities that affect the environment. The EPI program aims to develop formal indicators, across several issues and sectors, to improve public awareness on environmental issues and progress policy formulation and review. The EPI program has developed links to use indicators in other emergent national reporting systems such as the Monitoring Progress towards a Sustainable New Zealand report (Statistics New Zealand 2002b).

6.4.1 The relevance of the case studies to the thesis

The EPI program has been identified as a recent attempt at using indicator-based frameworks for reporting on sustainability issues in New Zealand. The system has developed through departmental reform, inter-governmental collaboration, and fishery and oceans policy development. The EPI program has recently released fisheries indicators for several stocks and is integrating these results within a national reporting framework. The case is highly relevant in terms of an approach to report on fisheries sustainability and will be evaluated under the assessment framework

.

6.5 Case 8. Environmental Performance Indicators (EPI).

The past five years has seen a rising interest in sustainability indicator systems in New Zealand. The State of the Environment Report in 1997 concluded that information required for coordinated environmental decision-making was lacking and required new approaches (Ministry for the Environment 1997). A number of critical issues required data, monitoring needed to be coordinated, and information developed for policy decisions.

The Minister for the Environment stated in the 1997 State of the Environment Report (Ministry for the Environment 1997; 3):

> *In making choices about the environment we need good information. Without this we cannot identify our environmental impacts, set realistic targets, assess progress, detect past errors or objectively weigh economic or environmental values.*

6.5.1 Background

The development of the EPI program in 1998 was in direct response to these findings. The program aimed to develop indicators for a number of themes and coordinate monitoring programs and analysis between government jurisdictions. The development of a common set of indicators allows for the development of common monitoring techniques, planning and integrated policy decisions on issues that traditionally cross several boundaries.

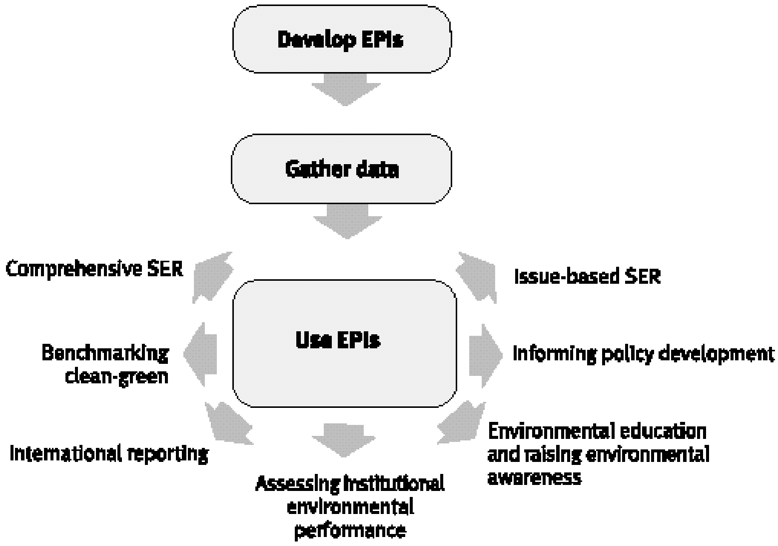
The government objectives for the EPI program include (Ministry for the Environment 1998):

- To systematically measure the performance of its environmental policies and legislation;
- To better prioritise policy and improve decision making;
- To systematically report on the State of New Zealand's environmental assets.

The Ministry for the Environment is the leading agency for the EPI program with input coming from government departments, local governments, indigenous groups, research institutes, NGOs and industry. One of the strengths of the EPI program has been the development of partnerships amongst stakeholders and departments, clarifying the monitoring and reporting responsibility for the relevant indicators. This development has encouraged information exchange and facilitates integrated decision-making and avoids duplication across jurisdictions.

The creation of a national series of environmental indicators aims to simplify, quantify and communicate trends in environmental sustainability issues (Gilbert 2000). The system is designed for a variety of uses and users, and is inherently flexible to cater for a range of outputs. Outputs from the SIS are identified below:

Figure 47. EPI Program outputs.



Adapted from (Ministry for the Environment 2001)

The EPI program therefore contains a number of outputs for reporting, performance assessment, benchmarking and a number of educational and awareness raising outputs. An interesting feature has been the linking of the EPI program to an experimental sustainability indicator program being developed by the New Zealand statistics agency (Statistics New Zealand 2002a). The Monitoring Progress Towards a Sustainable New Zealand is a high level strategic approach to assessing the sustainability of New Zealand across environmental, social and economic dimensions. The report provides an experimental selection of indicators related to sustainable development, and is the first attempt to bring this information together. Many of the indictors in the EPI program will be used in this report. The EPI project relies primarily on the development of the environmental tier of sustainable development, but does contain reference to socio-economic influences that are linked to environmental issues. Developing indicators for the management of fisheries lies in the marine component of the EPI program and will be the focus for this case study.

6.5.2 Structure and Indicators

This case study investigates the development of indicators that relate to the sustainability of fisheries resources and their respective management. Fisheries indicators lie within the marine environment theme, a key issue for the EPI project. The EPI framework consists of a series of indicators that are organised by a thematic approach and a modified version of the Pressure –

State – Response (PSR) model. At the highest level of organisation, the EPI framework is divided into the following criteria:

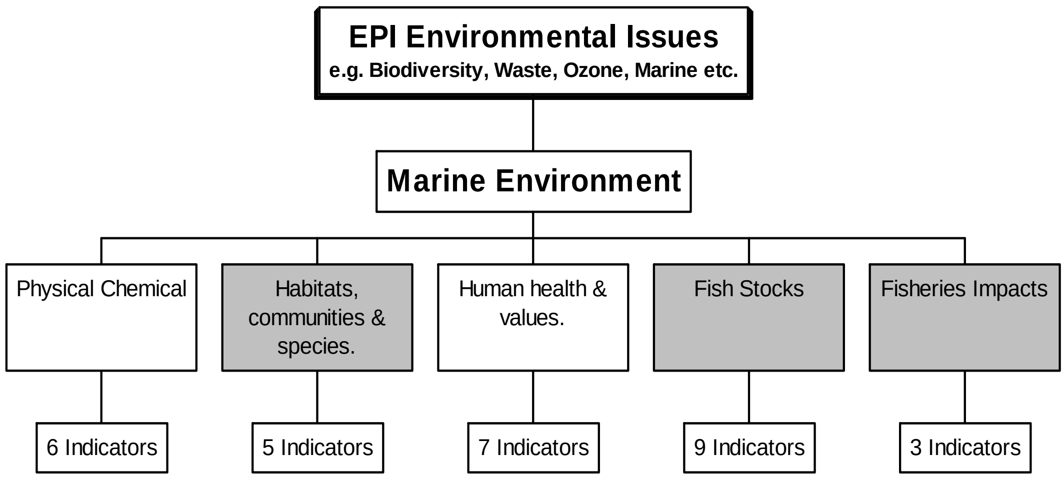
- Air
- Ozone
- Freshwater
- Pests, weeds, diseases
- Contaminated sites
- Land
- Transport
- Energy
- Biodiversity
- Climate change
- Waste
- Amenity
- Maori
- Marine

Each identified theme undergoes a process of subdivision to establish criteria that represent 'issues of concern', policy priorities and legislative commitments (Ministry for the Environment 2001). The establishment of indicators in each theme represents, therefore, a cross section of public concerns, and addresses policy commitments and legislative requirements in regards to environmental management. The process of indicator selection included Ministry for the Environment 2001):

- Reviewing international agreements and national legislation and policy goals.
- Identification of key environmental issues.
- Identification and review of monitoring and data gathering approaches.
- Preliminary identification of indicators through public workshops using the PSR model.
- Maori consultation.
- Refinement of indicators through a technical expert workshop.
- Scientific and peer review.

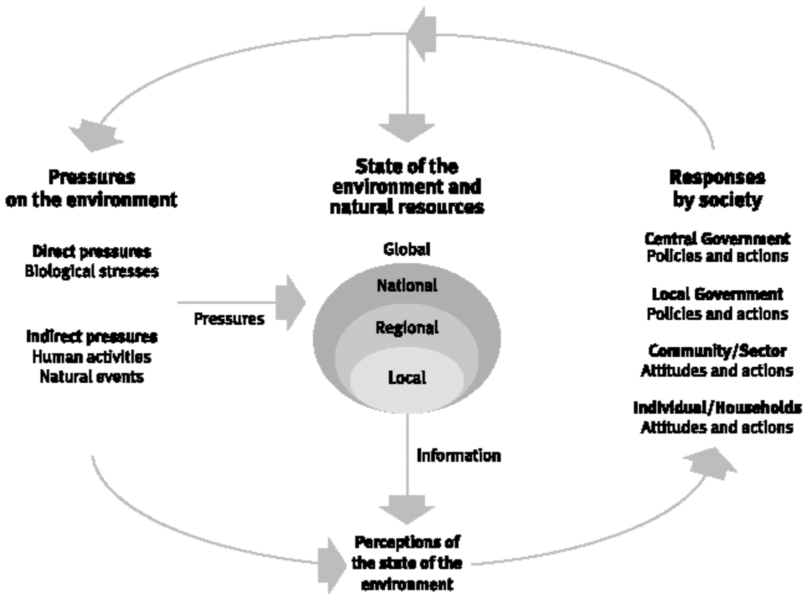
For the marine theme, this involved identifying the range of policy and legislative instruments that is in effect in New Zealand and extensive consultation with stakeholders, experts and the public to identify issues of concern. Further refinement established a set of criteria for which indicators could be established. Figure 48 below identifies the marine criteria.

Figure 48. Framework for the EPI Marine SIS.



Indicators under each criterion are selected on the basis of pressure, state and response parameters (Figure 49). The Ministry for the Environment (2001) notes that an ecosystem based approach was taken to further influence the indicator selection. Pressure indicators measure actions that affect a desired environmental quality. The EPI program considers direct, measurable pressures on the fishery and avoids the notion of indirect pressures. State indicators measure the status or condition of the fishery while response indicators assess the governmental response to the fishery or marine issue under consideration. The PSR model allows for a simplistic, yet effective interpretation of complex environmental interactions and can aid in public awareness and policy development. The issues surrounding the interpretation of the PSR model, in regards to the assumption of linear causality, are discussed in Chapter 2. The modified PSR model used in the EPI program is shown below in Figure 49.

Figure 49. The EPI modified PSR model.



Using the PSR model a set of 30 indicators were chosen for the marine report. Indicators that have a direct relevant to fisheries are listed below in Table 21. The indicators listed below are organised according to the key pressure – state – or response parameters and information development. Stage 1 indicators refer to those that are already being implemented (with current data and monitoring approaches sufficient for implementation) or within two years. Stage 2 indicators require further implementation, new data and will be developed over 3 to 5 years (Ministry for the Environment 2002). The EPI marine theme has 30 indicators in total, 15 that are at stage 1 and 15 at stage 2 (Ministry for the Environment 2001). Observed in table 23, the majority of fisheries indicators are ready to be implemented within a short time frame (that is, stage 1 indicators) (Ministry for the Environment 2001).

Table 23. Fisheries related indicators in the EPI program.

Theme	Indicator	Pressure State or Response	Stage
Habitats, Species & Communities	ME6: Percent Change in extent of selected marine habitats	State	1
	ME 6a: Biodiversity condition of selected marine habitats and communities at selected sites.	State	2
	ME7: Percent area of each of NZ different marine environments, ecosystems & habitats under protection.	State	2
	ME8: The number of taxi in IUCN and New Zealand threat categories.	State	2
	ME9: Abundance and distribution of adventive marine species.	Pressure	2
Fish Stock Indicators	ME16: Ratio of current biomass to target biomass for modelled stocks.	State	1
	ME17: Percentage of stocks modelled that are at or above target level.	State	1
	ME18: Number of assessed stocks (of high medium or low value) about which stock status is known or unknown.	State	1
	ME31: Number of non-assessed species of high, medium, low or unknown value, with the percentage of associated/ dependent species protected.	State	2
	ME22: Level of total catch for each species, by area.	Pressure	1
	ME24: Ratio of total catch to sustainable yield for modelled stocks.	Pressure	1
	ME27: Current TAC for each stock	Response	1
	ME29: Ratio of TAC to sustainable yield for modelled stocks.	Response	1
	ME30: Percent of stocks with current biomass below target where rebuilding strategies are in place.	Response	1
Fishing Impacts	ME32: Number of different non-fish and protected species caught by species, per fishery, by area, by year.	Pressure	1
	ME33: Level of fishing effort, by method, by area, by year.	Pressure	2
	ME34: Change in area of habitats (%) covered by marine farms.	Pressure	2

Adapted from (Ministry for the Environment 2001).

The 5 indicators under the *Habitat, Communities and Species* program aim to quantify the extent and condition of marine ecosystems and habitats (Ministry for the Environment 2001). Four of the indicators focus on assessing the *state* of marine systems, investigating the extent of habitat, biodiversity condition at selected representative sites, extent of marine systems under a protection regime and the extent of threatened species. One indicator in this criterion represents a *pressure* category - that of the effect of introduced species on the marine environment. This indicator measures the abundance and distribution of key introduced species (termed adventive species) that are known to detrimentally affect marine systems. The indicators under this criterion do not directly relate to fisheries activity, but provide important information about the broader ecosystem that fishery where operations take place.

Fish stock indicators are focused on the pressures and state of the target species and assess key characteristics of the harvested stocks. Response indicators focus on management actions that relate to harvesting stocks. The indicators are based on the Ministry of Fisheries annual stock assessment process under the *Fisheries Act 1996* (Gilbert 2000). For stocks that are not assessed (but are still targeted) proxy indicators are applied. However, the focus of the fish stock indicators is on modelled stocks. The development of the indicators is directly relevant to fisheries management in New Zealand, with stock assessments tied to TAC decisions and sustainability measures under the Act. (Gilbert 2000) notes that the indicators can be developed at a relatively low cost as a part of existing stock assessment procedures and directly links to the fisheries management process.

Two measures are listed as *pressure* indicators under fish stocks. The pressure indicators quantify the extent of fishing activity upon the stock biomass. Indicator ME22 details the level of catch for each species by area and provides a simple measure of pressure by quantifying the total catch taken. (Ministry for the Environment 2001) notes that it will include information on all catches from commercial, recreational and customary catches and information on non-target and non-assessed species. ME24 measures the total catch (commercial and non-commercial) against the sustainable yield for modelled stocks[146]. This indicator, presented as a ratio, details whether the catch is depleting or restoring the biomass to its target level. This indicator should be interpreted with ME16 to gain a total picture of the stock dynamics.

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[146] The sustainable yield, also called the Current Surplus Production, Maximum Constant Yield, or Current Annual Yield, is determined from stock population models.

In terms of *state* indicators four measures are presented for fish stocks. The focus is on biomass levels of modelled stocks and the state of the knowledge of assessed and non-assessed stocks. The indicator *ratio of current to target biomass for modelled stocks* (ME16) displays the status of the stock relative to a policy goal, and is reported for each modelled stock (i.e. hoki or rock lobster) through time. Decision makers can observe how the biomass of the stock is changing relative to the target level that has been set (i.e. is the state of the stock improving or declining?) *Percentage of stocks modeled that are at or above target level* (ME17) is an aggregate of ME16, showing a percentage per year of the total number of modelled stocks that exist at their target levels (and hence an overall *state* of modelled stocks). The two other state indicators (ME 18 and 31) refer to the state of knowledge rather than the stock, and count the number of assessed and non-assessed species, and group them by value to the main user of the species [147] (Ministry for the Environment 2001). ME18 refers to the number of assessed species (species that are considered in the Ministry of Fisheries assessment process) for which stock status is known or unknown. ME31 refers to the numbers of non-assessed species that are harvested or associated and dependent species that are not harvested but can be taken as by catch. It also details the levels of protection for these species.

Response indicators detail the effect of harvesting decisions upon the stock and the extent of management actions to conserve the stock. ME27 details the current TAC for modelled and non-modelled stocks, as setting the TAC is a management response to conserve the stock and move it towards the target level (Gilbert 2000). When interpreted with ME22, the indicator displays whether the TAC has been exceeded, therefore affecting the sustainability of the stock. ME29 compares the TAC with the sustainable yield estimate for modelled stocks and details how appropriate a response the current TAC level is against the pressure and state information. ME30 measures the number of stocks that have biomass below target levels that are engaged in rebuilding strategies.

Three indicators have been developed for measuring the ecosystem effects of fishing, specifically on non-target species, areas and habitats. The indicators are in the *pressure* dimension and will require further research and monitoring to be implemented (Stage 2). Combining with the habitat, communities and species indicators enhances interpretation of the wider effects of fishing activity on the marine system. ME32 measures the non-fish and protected species caught in fishery operations. ME33 investigates the level of effort by method

[147] Value for ME18 refers to the value to the commercial, recreational and customary sector. Value in ME 31 refers to the value to the ecosystem, e.g. the value of associated or dependent species within the ecosystem.

and area over time and presents information regarding the impact of fishing methods on marine communities (e.g. the effects of trawling on benthic communities). ME34 provides a measure of the pressure of aquaculture on marine habitats by quantifying spatial change in the area of habitat covered by farms.

The indicators presented in the EPI program provide a comprehensive account of the state of stocks and the impacts upon the ecosystem. Fish stocks indicators are directly linked to the stock assessment process and the Ministry of Fisheries research program, and provide a link between environmental policy development and fisheries monitoring programs. Several indicators provide important integrative links between departments and regional authorities, with the *Habitat, communities and species* and *Fishing impacts* indicators establishing common monitoring programs and protocols. Ongoing development of these indicators will increase collaboration between the relevant authorities and encourage the development of monitoring and assessment partnerships.

In terms of the sustainability assessment of fisheries, the indicators have positive and negative aspects. The fish stock indicators based primarily on stock assessment and population modeling link the EPI program directly with fisheries management and the setting of binding sustainability measures by the Minister. Indicators are relevant, based on the latest assessment information; are peer reviewed and receive support from stakeholders. Indicators for which information is lacking are the targets of collaborative monitoring processes, especially in the sphere of non-assessed and associated and dependent species. The establishment of indicators has identified the areas for priority research in fisheries management. When the indicators are read as a ‘package’ under the PSR model, useful inferences about the sustainability of fish stocks can be made and fed back into the fisheries management process. A negative consequence of the stock assessment focus is that important measures that influence fisheries, such as socio-economic concerns and governance measures, are noticeably absent from the EPI. The further development of *response* type indicators may be necessary. This situation may be resolved within the review process developed by the EPI and the commitment by the program to investigate new and relevant indicators.

6.5.3 Status

(Ministry for the Environment 2001) identifies the priority actions for implementing the indicators for the marine EPI:

1. Agreed roles and responsibilities for implementation of Stage 1 EPIs.
2. Refine sampling methods for stage 1 indicators and identify monitoring and reporting requirements for all indicators.
3. Develop web based reporting mechanisms.
4. Develop a consistent classification system.
5. Develop and validate methods and sampling designs and protocols for stage 2 indicators.
6. Clarify roles and responsibilities for monitoring and reporting of stage 2 indicators.

At the time of writing the EPI program is currently completing stage 2 and initiating stage 3 and 4 of the implementation process. A significant achievement has been the development of the web based reporting interface (Ministry for the Environment 2002). All fish stock indicators have been included on the web interface, with exception to the stage 2 indicators. Fish stock indicators have been applied to over 50 commercial modelled stocks, with an assortment of visualisation tools applied to aid interpretation. Visualisation is in the form of graphs, charts and maps of management areas with the appropriate indicator. Other stage 1 indicators from the fishing impacts and ecosystem, communities, and species sets are yet to be applied to the web interface at the time of writing. With the development of the classification system and stage 2 indicators (and the indicators from the other marine criteria in Figure N), these will be progressively applied to the web interface over the next five years (Ministry for the Environment 2001).

The EPI web interface will be the center of the EPI information system and access point for the public and decision makers. Information that is managed by partnership agencies (eg. Ministry of Fisheries) is collated, summarised and added to the web interface. As the series of marine indicators evolve, further impetus will be provided to the generation of outputs from the SIS, including State of the Environment reports, sectoral issue reporting (e.g. fisheries and marine reports), benchmarking, awareness reports, and policy and management review.

6.5.4 Analysis against the conceptual framework

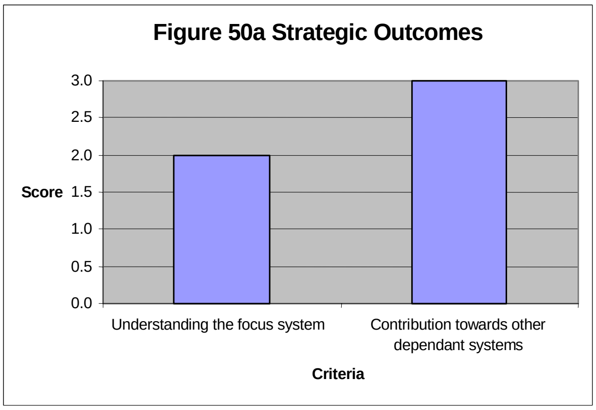
The EPI system is scored in Table 24 and Figure 50(a-e). Against Strategic Outcomes, the SIS obtains an above average score in assessing the focus system (2) and a high score for its contribution to dependent systems (3). The SIS employs a comprehensive method to investigate fisheries and marine issues, and has developed a core set of indicators that can are presented to stakeholders and the public through the web based reporting system. The SIS is predominantly target species based, but development of the Stage 2 indicators will result in broader ecosystem measures being applied. In terms of contribution to dependent systems, the EPI is based upon and draws together specific goals national legislation and environmental policy. The SIS has identified outputs to broader reporting systems and contributes significantly to the experimental sustainability report currently being developed by Statistics New Zealand.

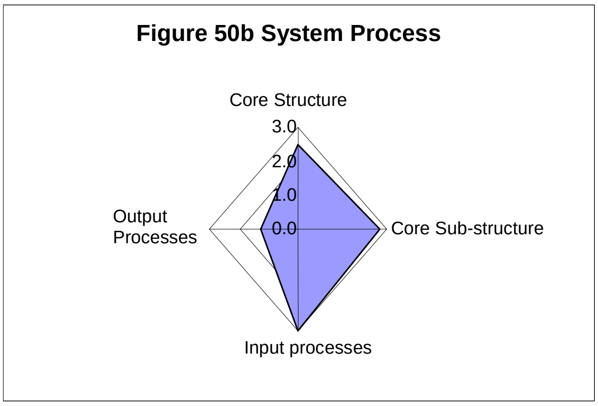
Scoring against the System Processes component (Figure 50b) reveals that the EPI system is well placed in terms of its core structure (2.5), sub-structure (2.8) and input processes (3). The chart identifies that significant improvement is required in generating outputs (1.3). The core structure generates under a thematic and modified P-S-R model a series of criteria based on environmental themes. The marine theme is further subdivided into a specific set of sub-criteria that represent fisheries and marine issues. Under each sub-criteria a set of indicators are proposed. The sub-structure has been well developed with specific objectives, well researched and pragmatic indicators, with a means to interpret performance. The high scoring input process is based upon a defined policy context for the SIS, a dedicated feedback process for developing and improving indicators, and wide consultation with stakeholders fed into the development of the SIS. Output processes are an area of significant improvement for the EPI with minimal use of visualisation techniques and aggregation. However the reporting of the results via the web-based system is an innovative and effective technique. The SIS currently fulfills a reporting function, with decision-making relevance expected to increase over time.

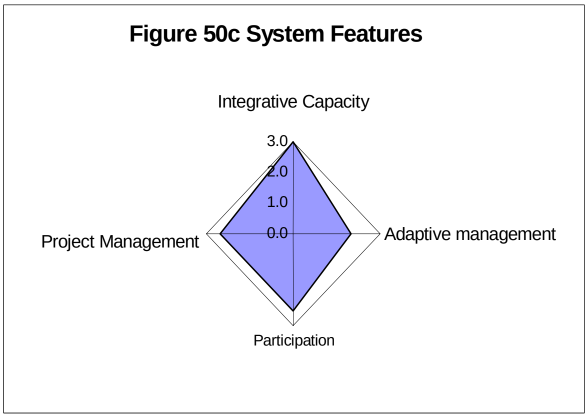
Table 24 Case 8 Scoring

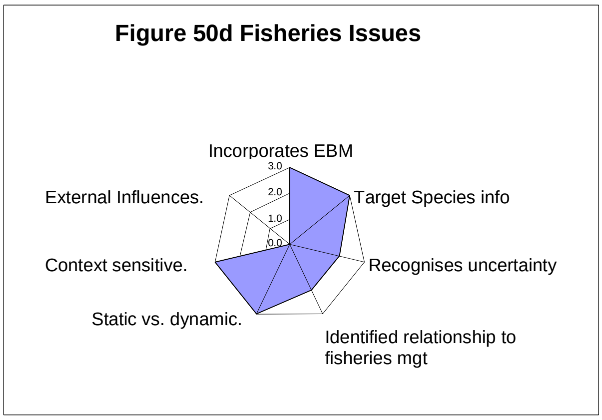
Case 8 Environmental Performance Indicators Program.				
Strategic Objective	***Sub Objective***	***Operational Objective***	***Score***	***Notes***
1. Strategic				
	Understanding the focus system	*System state and viability*	2	SIS employs comprehensive approach to assessing the marine system.
	Contribution towards other dependant systems	*System contribution to broader societal sustainability.*	3	Fisheries system nested within broader environmental system. Evolution to sustainability approach.
2. System Processes				
	Core Structure	*Interpretation and definition of sustainability.*	2	Definition implied in SIS. Conservation & mgt of New Zealand natural resources and ecology.
		Framework classification.	3	Thematic based modified PSR model. Fig 48, 49
		Dimensions of sustainability.	2	Focus on ecological sustainabaility. Some socio-economic indicators used in SIS. Table 23
		Criteria and sub-criteria.	3	Process identifies broad envionmental critera and subdivides to specific operaitonal criteria.
	Core Sub-structure	*Objectives*	3	Clear objectives for each criteria.
		Indicators: Scientific	3	Well researched, peer reviewed indicators. Formal review process.
		Indicators: Functional	3	Highly policy relevant. SIS developed on the basis of policy review and need for measurement.
		Performance values	2	PM implied in each indicator description. Ongoing process.
	Input processes	*Policy context*	3	SIS linked to, and formed as a basis of, national environmental and resource policy.
		Indicator feedback	3	Feeback protocols establsihed. Tpye 1 and 2 indicators. Table 23
		Stakeholder / user feedback	3	Ongoing consultation part of SIS develpoment. Focus on indigenous consultations
	Output Processes	*Visualisation & presentation.*	1	Miniminal use of visualisation techniques. Web based.
		Communication & reporting	3	Web based reporting strategy. Updated and in ongoing development. Accesible and easy to navigate.
		Aggregation and scorecards	0	no aggregation methods.
		Decision making influence	1	Reporting function. Evolving recognition, development and use in decision making over time. Fig 47
3. System Features				
	Integrative Capacity	*Interaction of sustainability dimensions.*	3	SIS investigates the integrated nature of indicators. Process defined and recognised.
		Integration with other reporting systems and sectors.	3	SIS acts as a coordinating tool amongst policies / agencies.
	Adaptive management	*Social indicator development.*	1	Minimal use of social indicators.
		Institutional indicator develop.	2	Basic use, ongoing development for environmental management.
		System monitoring and feedback.	3	Formal feedback process. Focus on indicator development rather than entire SIS.
	Participation	*Participation of stakeholders*	2	Stakeholders consulted and views incorporated.
		Participation of decision makers and relevant institutions.	3	Decision makers involved in SIS. Indicator data managed by relevant agency, e.g. Mfish.
	Project Management	*Institutional Capacity*	3	Sufficient capacity, well resourced and supported.
		Marketing and R&D	2	Emerging recognition amongst stakeholders.
4. Fisheries Issues				
	Incorporates Ecosystem Mgt Principles	*SIS reflect broader ecosystem based management principles.*	3	Marine criteria is subdivided into EBM based subcriteria. Several Type 2 indicators. Table 23
	Target Species info	*Indicators assess state of the target stock , used in management plans.*	3	Detailed target stock indicators. Focus of fisheries component of SIS.Table 23
	Recognises precaution	*Assessments explicitly recognise all forms of uncertainty.*	2	A precautionary approach to development with Type 1 and 2 indicators and explicit data req.
	Identified relationship to fisheries	*Indicators feedback to mgt.*	2	Indirect relationship - influence policy decisions and quota allocation through reporting.
	Static vs. dynamic.	*Static and dynamic reporting within SIS.*	3	Approach used that regularly assesses stock dynamics and flows.
	Context sensitive.	*Does the SIS take specific fisery context isues into account?*	3	SIS is fishery based.
	External Influences.	*Information on overcapacity, subsidies, trade, fleet structure, IUU fishing and external influences.*	0	No recognition of external influences.

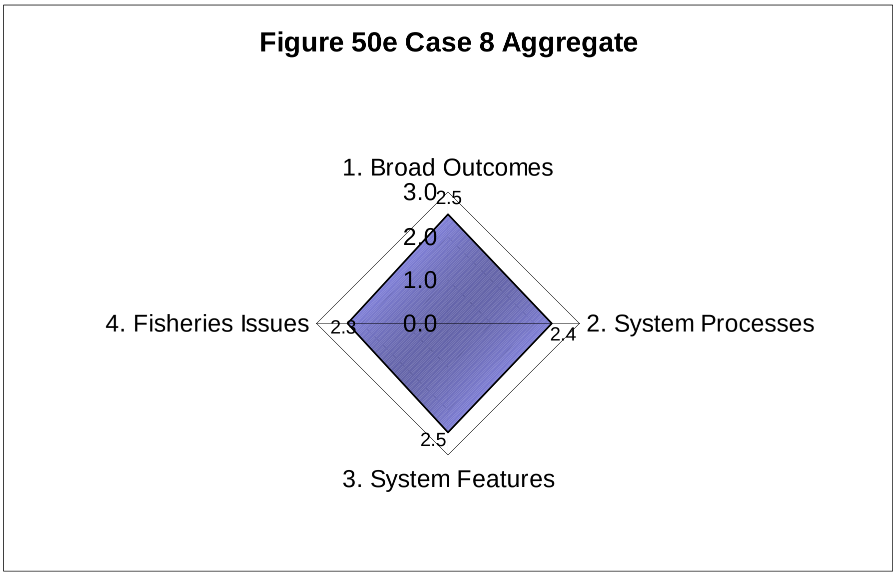
Figure 50(a-e) Orientation graphs for Case 8.











The SIS scores well in the System Features (Figure 50c) component with high integrative capacity (3), average adaptive management (2), and high participation and project management scores (2.5). The SIS has developed a systems approach to identify the integrated relationships between indicators on common themes. In addition the SIS has been designed to integrate and coordinate decision-making across agencies with multiple environmental responsibilities. This is a direct response to the 1997 State of the Environment Report (Ministry for the Environment 1997). For adaptive management the SIS has minimal use of socio-economic indicators and basic use of institutional indicators. The intended integration of the SIS with other reporting systems based on socio-economic outcomes will increase this score. In addition, the further development of fisheries indicators in the *pressure* and *response* dimension will increase this score. The EPI program has engaged a wide variety of stakeholders and decision makers over the course of its development. A feature of the system is the coordinated approach to data management with identified agencies (such as the Ministry of Fisheries) managing the relevant indicators.

In terms of Fisheries Issues (Figure 50d) the EPI program demonstrates an overall competency in assessing ecosystem based issues (3), target species (3), developing a dynamic reporting approach (3) and remaining context relevant (3). The SIS displays a direct link to fisheries management by integrating with the annual stock assessment and planning process. In addition, the SIS recognises the issue of uncertainty in fisheries management information and adopts a precautionary approach with the testing and development of the candidate indicators (Type 1 and 2 indicators). The SIS explicitly acknowledges that new forms of information must be included for fisheries management to embrace precaution. A significant area of improvement for the SIS is the inclusion of external influencing factors (including socio-economic) in the fishery system and the development of indicators that measure these influences.

The Case Aggregate (Figure 50e) displays an overall balanced and high scoring system. Each strategic component, after averaging the results, obtains a high score. Therefore the SIS demonstrates Strategic Capacity (2.5), an efficient and effective System Process (2.4), takes into account key sustainability System Features (2.5) and incorporates relevant fisheries issues (2.3). The EPI system is a progressive attempt for reporting on sustainability issues in fisheries, coordinating inter-departmental approaches, and including fisheries issues in a broader environmental and socio-economic context.

6.6 Conclusion

The Environmental Performance Indicators program has developed a broad suite of indicators across a range of environmental issues. The EPI program aims to measure and report on the pressures that are being put on the environment, the historical and current state of the environment and the effectiveness of any responses that protect and manage the New Zealand environment. The indicators aim to provide accurate and timely information that contribute to analysis of environmental issues and provide a platform for decision-making and policy makers.

The marine and fisheries component of the EPI is relatively well advanced. The indicators have undergone stakeholder consultation, peer review and testing and have been progressively published on the EPI website[148]. Indicators are available for many target species in the New Zealand fishery sector. The indicators for fish stocks aim to report on whether fisheries are being used sustainability across New Zealand. The indicators report on fish catches and catch limits, provide information on stock size relative to target goals and estimate importance of stocks to user groups. Together these indicators report on the state of fish stocks in New Zealand and allow for an assessment of the effectiveness of domestic fisheries policies and strategies. The fisheries indicators within the EPI provide a basis for improved fisheries management and will influence the decisions on harvest allocations.

The next chapter moves from the national based indicator systems to multi-lateral regional organisations. The focus for the next indicator system case study is the Southern Ocean and the Commission for the Conservation of Antarctic Marine Living Resources.

[148] http://www.environment.govt.nz/indicators/marine/

Chapter 7: Regional Approaches Case Study: CCAMLR

7.1 Introduction

Regional case studies present examples of the next step in the hierarchy of decision-making for fisheries and the development of indicator systems. The national case studies highlighted indicator initiatives within domestic jurisdiction that influenced fisheries management. The case studies below highlight an initiative that occurs at the regional level – a multilateral, large-scale regime over large marine ecosystems.

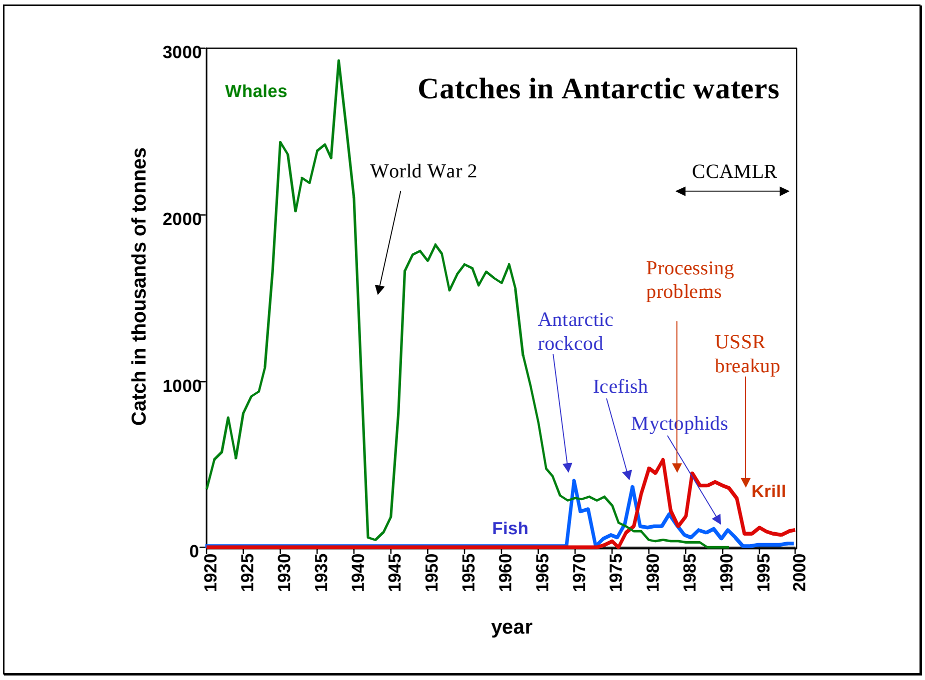
Many fisheries cross one or multiple national boundaries, exist in international waters or migrate through multiple jurisdictions. Straddling, migratory and high seas stocks are subject to a variety of additional pressures in the form of harvesting from multiple States, problems of management coordination and enforcement and IUU fishing. The management of these fisheries requires a cooperative, international approach through regionally effective instruments. LOSC and the 1995 UN Fish stocks Agreement represent significant milestones providing legislation for the management of straddling, migratory and high seas stocks and the basis for cooperation through regional fishery organisations (Vidas 2000; Juda 2001).

The case below investigates the development of sustainability indicator systems as a tool to improve fisheries management in a regional context and operationalise ecosystem management and precautionary approaches. These indicator systems are developed in a fundamentally different jurisdictional setting than the national cases. Regional organisations represent cooperation between coastal, port, market and fishing states over fisheries issues, operate under the principles of international law, and manage stocks over large marine domains. Regional agreements however, have had significant challenges in ensuring effective compliance with, and enforcement of, management decisions. The case below is an example from a fisheries management organisation, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) that is exploring the use of indicator based approaches.

7.2 Introduction to CCAMLR

Uncontrolled exploitation of marine living resources has occurred in the Southern Ocean for over 200 years. Living marine exploitation has followed a ‘boom or bust’ process, with species of seals, whales, penguins, and finfish being hunted to almost extinction or reduced to low population levels and experiencing collapses (Figure 51 below).

Figure 51. Exploitation of Antarctic Marine Resources



Adapted from (Kock 2000)

Uncontrolled harvesting of seal pelts was initiated on sub-Antarctic islands in the late 1700s. Captain James Cook had discovered South Georgia and its wildlife in 1772 (Walton 1987). From 1801 to 1822 over 1 200 000 Antarctic and sub-Antarctic Fur Seal skins were taken by hunters on South Georgia (Walton 1987; Kock 2000). This soon spread to other newly discovered islands in the Antarctic Peninsula such as the South Shetlands (Fogg 1992). By the end of the 19th century fur seal populations in the region were virtually non-existent (Walton 1987; Fogg 1992). With diminishing Fur seal populations, exploitation of Elephant seals occurred for blubber and oil extraction (Fogg 1992).

The advent of shore based commercial whaling at South Georgia in 1904 initiated a period of intense and unsustainable exploitation (CCAMLR 2001B). Initially, shore based whaling generated limited impact upon populations by restricting harvesting to whaling stations (Walton 1987). With the arrival of ‘factory ships’ in the 1920s exploitation exponentially increased, with 1.5 million whales taken until management measures through the International Whaling Commission (IWC) were introduced in 1946 (Fogg 1992; CCAMLR 2001B). From 1946 exploitation of whale species was restricted by the IWC, with a Southern Ocean Sanctuary declared in 1994 (Garbin 1999). Limited scientific whaling of Minke whales by Japanese fleets still occurs within the sanctuary. The IWC suffers from considerable problems in relation to its effectiveness and legitimacy (Garbin 1999).

The late 1960s saw the large-scale exploitation of finfish and krill stocks in the Southern Ocean. Soviet fleets targeted the marbled rock cod, *Notothenia rossii* around South Georgia, with the catch rising from a few hundred tonnes in 1967/68, to 90 000 tonnes in 1968/69, and to a peak of 400,000 tonnes in 1969/1970 (Walton 1987; Kock 1992). The following season the fleet expanded to the Kerguelen plateau and caught 212 000 tonnes of *N. rossii* in 1970/71 and 100,000 tonnes in 1971 (Walton 1987; Powell 1989). In the following years the stocks of *N. rossii* crashed to low catches in the vicinity of 11,000 tonnes in 1975, resulting in further decline of the overfished stock (Kock 1992). With the decline in *N. rossii* fleets moved to the Orkney and South Shetland Islands to harvest icefish, *Champsocephalus gunnari* (Powell 1989). Since this period there has been zero catches for *N. rossii* and despite no directed fishing for over a decade, stocks have not recovered (Parkes 2000). The levels of fishing intensity resulted in overfishing impacts upon bycatch species, such as *Notothenia gibberifrons* (Walton 1987). Krill species, *Euphausia superba*, were experimentally fished in the 1960s, with catches increasing through the 1970s and peaking at 528 000 tonnes in 1980 (Parkes 2000; CCAMLR 2001B). The 1980s and 1990s has seen the rapid expansion of the *Dissostichus spp.* fisheries, that of Patagonian and Antarctic Toothfish, and the advent of IUU fishing for this high market value species (Welch 1998).[149]

The unsustainable ‘boom and bust’ approach of Antarctic fisheries led to growing concern within the Antarctic Treaty nations over the management of fishing activity. Central to this concern was the development of the krill fishery. Krill are a keystone species within the Southern Ocean ecosystem, being a major prey species for several bird, whale, seal and squid stocks (Figure 52) (Knox 1994; Nicol 1999; Hewitt 2000).

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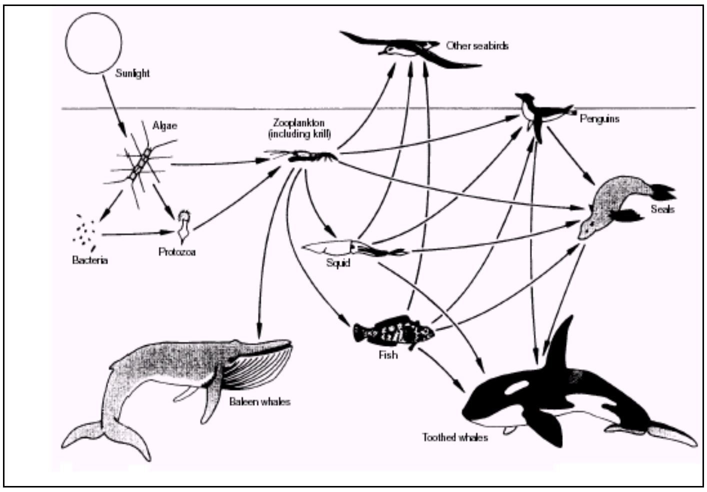
[149] The IUU and legal toothfish fisheries are highlighted below.

Figure 52 Simplified 'krill centric' Antarctic marine food web (CCAMLR 2002a)



The Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) was negotiated in the late 1970s as a result of this concern. In 1977 the Antarctic Treaty Consultative Meeting initiated negotiations based on the premise that a lack of management had been responsible for the destruction of Antarctic resources (Kaye 2000; Kaye 2001). Protection of the Southern Ocean ecosystem and commercial use was of equal importance. Ecosystem principles were included in the initial negotiations of CCAMLR, based on information from the BIOMASS program (Kaye 2001).[150]

The Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) was concluded in 1980 and entered into force in 1982. CCAMLR was the first regional fishery management organisation to recognise and attempt to implement the ecosystem approach (Constable 2000; Hewitt 2000). The boundaries of the CCAMLR regime reflect ecological realities, applying to all marine living resources within the region.[151] The Convention applies from the Antarctic Polar Front (formerly the Antarctic Convergence), a natural oceanographic boundary, to the Antarctic continent (Powell 1989). The Antarctic Polar Front forms a natural boundary where colder, fresher Antarctic waters flowing north from the Antarctic meet warmer, salty, temperate waters from the Atlantic, Pacific and Indian oceans, resulting in a natural barrier for marine organisms, with the exception of migratory whales (Knox 1994). The CCAMLR boundary was selected to reflect the limits of the Antarctic ecosystem, stated in Article I of the

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[150] The Biological Investigations of Marine Antarctic Systems and Stocks (BIOMASS) was a ten-year study of Antarctic marine ecosystems, including fisheries that were coordinated through the Scientific Committee on Antarctic Research. It was responsible for the collection of baseline marine biological and ecological data from the Southern Ocean (Kellermann & North 1994; Kaye et al 2000).
[151] CCAMLR does not apply to seals or whales, which are covered by the Convention for the Conservation of Antarctic Seals (CCAS) and International Convention on the Regulation of Whaling.

Convention. Figure 53 highlights the CCAMLR region, its statistical sub regions, and the boundary.

The text of the convention states the CCAMLR commitment to an ecosystem approach. Article I (2) and Article I (3) highlight the application to marine species within the Antarctic ecosystem (CCAMLR 1980):

> *Antarctic marine living resources means the populations of finfish, molluscs, crustaceans, and all other species of living organisms, including birds, found south of the Antarctic convergence.*
>
> *The Antarctic marine ecosystem means the complex of relationships of Antarctic marine living resources with each other and with their physical environment.*

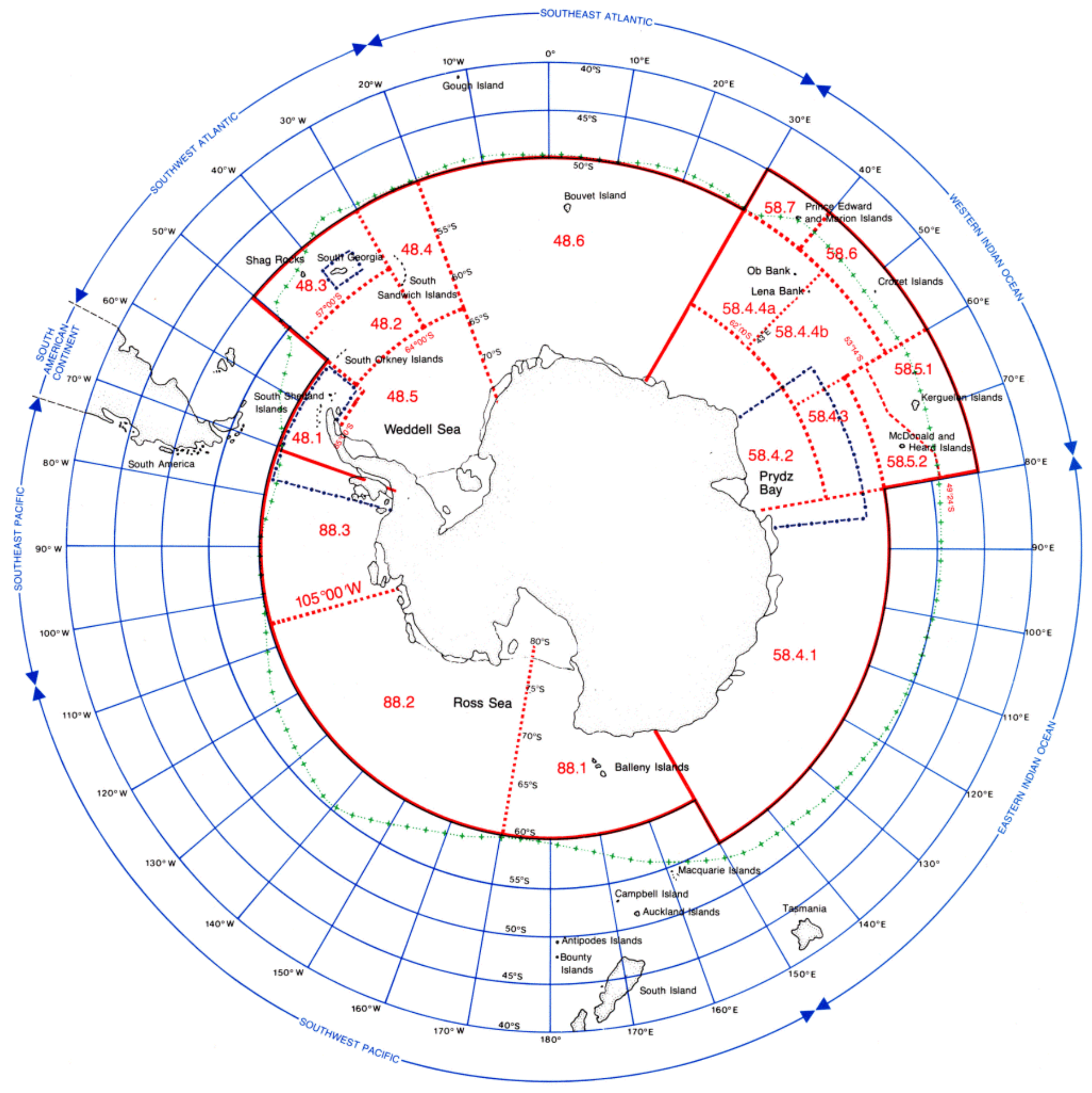
Article I lays the foundation for CCAMLR as a management regime for the regulation and rational use of fisheries resources combined with an ecosystem approach (Kock 2000; CCAMLR 2001B). This ecosystem management mandate distinguishes CCAMLR from other multilateral, single species based fisheries agreements (Constable 2000; Kock 2000; CCAMLR 2001A). CCAMLR represented the first 'pro-active' fisheries regime established with a mandate to regulate across the ecosystem range, and specifically include the effects upon target, dependent and associated species.

Article 1 of CCAMLR established the foundation of an ecosystem approach with Article 2 setting the specific operational objectives for management. Article 2 states (CCAMLR 1980):

> *1. The objective of this Convention is the conservation of Antarctic marine living resources;*
> *2. For the purposes of this Convention, the term 'conservation' includes rational use;*
> *3. Any harvesting and associated activities in the area to which this Convention applies shall be conducted in accordance with the provisions of this Convention and with the following principles of conservation:*
>
> *(a) prevention of decrease in the size of any harvested population to levels below those which ensure its stable recruitment. For this purpose its size should not be allowed to fall below a level close to that which ensures the greatest net annual increment;*
>
> *(b) maintenance of the ecological relationships between harvested, dependent and related populations of Antarctic marine living resources and the restoration of depleted populations to the levels defined in subparagraph (a) above; and*

(c) prevention of changes or minimisation of the risk of changes in the marine ecosystem, which are not potentially reversible over two or three decades, taking into account the state of available knowledge of the direct and indirect impact of harvesting, the effect of the introduction of alien species, the effects of associated activities on the marine ecosystem and of the effects of environmental changes, with the aim of making possible the sustained conservation of Antarctic marine living resources.

Figure 53. The CCAMLR Region (CCAMLR 2002a)



CCAMLR objectives are markedly different from the traditional objectives for fishery conventions. The negotiation of CCAMLR was in a climate of biological research and concern over ecosystem impacts, and resulted in a strong set of ecosystem-based objectives. Article II (3a) prescribes the maintenance of the target species by ensuring the stable recruitment of stocks. This is achieved by preventing the population falling below a level that allows the maximum annual increment of recruits (CCAMLR 1980; Kaye 2000). Maintenance of the target species is expanded in 3(b) to include the maintenance of the ecological system: taking into account the relationships between harvested, dependent and related populations. When harvesting the target species, management measures must take into account species that are ecologically related, including non-commercial species such as seabirds. Reference is also made to the restoration of depleted populations to stable levels (Kaye 2000). Furthermore Article II (3c) calls for a precautionary approach with the prevention of changes, or minimisation of the risk of changes in the marine system in the context of broader environmental change, harvesting activities, introduced species, and uncertainty of data. The development of precautionary measures enables CCAMLR to minimise the risk of long-term effects on the ecosystem and take uncertainty into account when making decisions.

CCAMLR, through Article II, focuses on ecosystem-based management and the precautionary approach, both cornerstones of sustainable development within fisheries. Parkes (2000) describes how a substantial proportion of the work performed by CCAMLR pre-dates the application of the precautionary approach in modern fisheries management. Despite no mention of the term in the Convention text, activities under CCAMLR are in accordance with the intent of the principle.

7.3 The Governance Framework of CCAMLR

CCAMLR currently has 24 members [152] and 7 consulting members.[153] In addition several organisations are present as observers to the Commission. [154] The CCAMLR Secretariat is based in Hobart (Tasmania, Australia). The CCAMLR regime consists of two primary structures: a

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[152] Full members of CCAMLR include: Argentina, Australia, Belgium, Brazil, Chile, European Community, France, Germany, India, Italy, Japan, Korea, New Zealand, Namibia, Norway, Poland, Russia Federation, South Africa, Spain, Sweden, Ukraine, United Kingdom, USA and Uruguay [CCAMLR, 2001 #427].

[153] Consulting members, who are party to the Convention but not members of the Commission include: Bulgaria, Canada, Finland, Greece, Netherlands, Peru, and Vanuatu.

[154] Observers include non-government organisations such as the Antarctic and Southern Ocean Coalition and the IUCN.

Commission and a Scientific Committee. The Commission functions as the central policymaking and administrative body. It was established under Article IX of the Convention and has established a set of rules of procedure for Commission meetings (CCAMLR 2002b). Article IX states that the Commission must base its decisions on the best scientific evidence available, therefore establishing a relationship between the Commission and the Scientific Committee (Constable 2000). The Commission meets annually to review member's activities over the past year and for the next year, to review compliance and conservation measures and to review existing regulatory measures. Important decisions, or 'matters of substance' are made by consensus in CCAMLR, and become legally binding in international law on members after 180 days should no objections be lodged (Hewitt 2000; Kaye 2000). Non-binding but agreed principles are often embodied in resolutions made by the Commission (Constable 2000; CCAMLR 2001B). In addition, the Commission annually discusses matters that relate to administration and finance. Two subcommittees exist that focus the work in the Commission and assist in policy formation: Standing Committee on Administration and Finance (SCAF) and the Standing Committee on Observation and Inspection (SCOI) (Kaye 2000).

The Scientific Committee provides advice that is the basis of management decisions in CCAMLR, and supported by two working groups: ecosystem monitoring and management (WG-EMM) and fish stock assessment (WG-FSA) (Kock 2000). Working groups are convened for important issues, such the ad hoc Working Group on the Incidental Mortality Arising from Longline fishing (WG-IMAF)[CCAMLR, 2001 #427]. The Scientific Committee is intended to be a consultative body for the exchange of scientific information and the formulation of recommendations for the Commission (Kock 2000). (Hewitt 2000) notes that the members of the Committee discuss a range of recommendations and reach agreement via a process of peer review and debate rather than by consensus methods. Findings are passed on to the Commission in an annual report for decision making on the basis of the best available science. The relationship between the Commission and the Scientific Committee has not always been a harmonious one. The early years of CCAMLR saw frustration on the part of the Scientific Committee over the quality of information from stock assessments and the lag time for the development of important conservation measures for depleted stocks (Constable 2000). Confrontations between the two bodies in the first 10 years of CCAMLR increasingly focused on the question of 'how should the Commission deal with uncertainty in assessments and advice from the Scientific Committee' (Constable 2000; Parkes 2000).

Early stock assessments within CCAMLR used traditional techniques and were hampered by a lack of baseline life history information (Powell 1989). Assessments contained uncertainties from natural variation, uncertainty in estimates of model parameters, incomplete historical catch records, and imprecise submission of data [155](Constable 2000). Estimates presented to the Commission, often highly variable and based on uncertain parameters, provided a challenge to the decision making body. The Commission was ill equipped to deal with the notion of uncertainty in stock assessment. The setting of catch limits and conservation measures required consensus, and in the case of scientific uncertainty and political division, was difficult to achieve, with measures lagging by 1 to 2 years. (Constable) 2000) and Parkes (2000) note that the situation led to a period of frustration for CCAMLR scientists, and resulted in a strong statement at the 1990 CCAMLR meeting on the capabilities of science to provide unequivocal advice on catch limits. This statement was endorsed by the Commission and set the basis for future cooperation and development of precautionary decision tools within CCAMLR.

CCAMLR's jurisdiction lies between the Antarctic Polar Front and the Antarctic continent as stated in Article I (CCAMLR 1980):

> *The Convention applies to the Antarctic marine living resources of the area south of 60^0 South latitude and to the Antarctic marine living resources between that latitude and the Antarctic convergence.*

CCAMLR established a series of statistical areas based on FAO subdivisions, dividing into three sectors (Atlantic Ocean, Indian Ocean and Pacific Ocean), termed Statistical Areas 48, 58 and 88 respectively (Kock 1999; CCAMLR 2001B). Each statistical area is divided into sub-areas and divisions (seen above in Figure 45). Therefore, CCAMLR takes into account the Southern Ocean below 60^0 South, which includes areas under Antarctic Treaty jurisdiction and the high seas. [156] Extending CCAMLR to take into account the Antarctic Polar Front includes several sub-Antarctic Islands and potentially impacts upon sovereignty issues of coastal states (Rothwell 1998). CCAMLR has jurisdiction (the authority to implement conservation measures that are legally binding on its Members) over all high seas areas within its range. Within the CCAMLR boundary however, a number of states retain sovereign rights over sub-Antarctic islands (France: the Kerguelen and Crozet Islands; Norway: Bouvet Island; South Africa: the Prince Edward Islands; and Australia: Heard and McDonald Islands) (Rothwell 1998). Sovereignty over South Georgia and the South Sandwich Islands are disputed by the UK and Argentina. States that are

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[155] These factors that contribute to uncertainty in the stock assessment process have hampered scientists and managers through the history of modern fisheries. The problems faced by CCAMLR scientists parallel concerns with other bodies managing fisheries around the world, that is, a lack of ecological information.

[156] Rothwell (1998) describes the complex legal status and arrangements between the ATS, high seas and CCAMLR and the overlap of marine legal regimes.

parties to CCAMLR do not cede sovereign rights to sub-Antarctic territory, but do operate within the framework and purpose of the Convention.[157] If states did not exclude marine territory from discussions on conservation measures they were bound to implement and enforce a measure.

While CCAMLR was formed on an ecosystem approach and developed an innovative boundary, recent work has recognised that in addition to cetaceans, other marine resources such as lanternfish, Patagonian toothfish, squid, and seabirds cross the northern boundary of the Convention Area in significant numbers (Willock 2002). The trade of commercial species occurs outside CCAMLR influence, yet this pressure often determines the status of species within the convention area.[158] Many important issues related to the management of Southern Ocean resources and broader economic influences can only be tackled in collaboration with external regimes such as the CITES and the UNFSA (Willock 2002).[159]

Over time, CCAMLR has developed a set of innovative tools to manage the living marine resources of the Southern Ocean within an ecosystem context. The challenges to this task have been formidable, especially within the context of political and economic pressures that arise with decision making between 24 national governments and an initial scientific foray into conceptual ecosystem management. The scope of the management domain, the entire Southern Ocean, and its jurisdictional challenges, has presented a unique aspect on the management of multiple marine resources in a regional context. Despite these challenges, CCAMLR has developed a comprehensive regime for monitoring, research and decision making for fisheries within an ecosystem basis, as prescribed by Article II, at a time when fishing conventions had little

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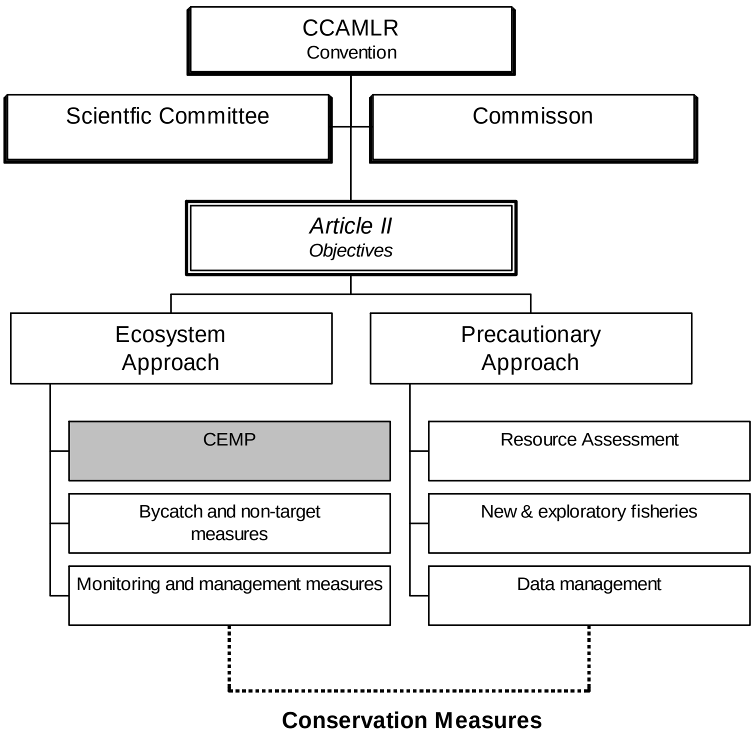
[157] France sought an exemption from the application from CCAMLR during negotiations in 1980 (CCAMLR 1980). The conference Chairman issued a statement at the close of the negotiation stating that measures were already in place to manage the living resources in the adjacent waters to the French claimed islands of Kergeulen and Crozet and would remain in place until modified by France acting within the framework of the convention (Rothwell 1998). In addition France retained the option to exclude territorial waters from any proposed discussions on potential conservation measures by CCAMLR and implement unilateral measures deemed necessary. However, if France did not chose to exclude waters, any conservation measures adopted with consensus would apply to, and be enforced by France. This notion was expanded to other states that held sovereignty over sub-Antarctic Islands, and set the basis for cooperation within CCAMLR: sovereignty issues were respected but marine areas were generally managed under the spirit and purpose of the convention.
[158] See Willock (2002) for a dissertation on trade impacts on the Patagonian toothfish.
[159] The Convention for International Trade in Endangered Species (CITES) and the United Nations Implementation Agreement on Fish Stocks (UNFSA) represent important future influences on the effectiveness and operation of CCAMLR. CITES relates directly to the regulation of international trade and has recently evolved to consider marine species, including Patagonian and Antarctic Toothfish. UNIA directly relates to the management of high seas regions under regional agreements and commits parties to join the relevant regional body.

experience. The instruments CCAMLR uses to manage living marine resources are described in detail below.

7.4 Management of the Marine Environment within CCAMLR

CCAMLR has designed a range of instruments for the management of fisheries in an ecosystem and precautionary context (Figure 54 below). Precautionary approaches embody the consideration of uncertainty in information, data collection and process. CCAMLR approaches to new and exploratory fisheries, stock assessment, and data management embody precautionary measures. Ecosystem management considers multi species relationships and monitoring of the ecosystem, with the CCAMLR Ecosystem Monitoring Program (CEMP), bycatch measures, and monitoring embodying the ecosystem approach. CEMP is highlighted in Figure 54 as the focus of the case study. CCAMLR at this point is new to developing socio-economic approaches for assessments, but development of the Catch Documentation Scheme (CDS) for IUU fishing is moving towards this aspect of sustainability. The development of conservation measures is the primary approach by which CCAMLR implements fisheries management. Measures are formed in the Scientific Committee (with advice from WG-FSA and WG-EMM) and passed on to the Commission for consideration and adoption, becoming legally binding on members 180 days after adoption.

Figure 54. The CCAMLR approach to ecosystem and precautionary management.



Article II sets the framework for an ecosystem and precautionary approach. The Article II objectives are operationalised by setting conservation measures (Hewitt 2000). The first conservation measure was passed at the third meeting of CCAMLR in 1984, a mesh size regulation for finfish trawling (Parkes 2000). In 1985 the trawl fishery for *N.rossii* was closed by a measure with no time limit, and remains in force until there is consensus to revoke it. In 1986 a conservation measure was passed that specified catch limits, and provided a basis for negotiation and agreement on catch measures for target and associated species in the convention area (Parkes 2000). Measures have been adopted for mesh sizes, area closures, limiting catch, reporting systems and methods, and closed seasons (Rothwell 1998). They are enforced by system of flag state and CCAMLR based observation and inspection mechanisms.[160]

To implement precautionary approaches, CCAMLR investigated decision rules and operational objectives for harvesting krill (Hewitt 2000). The focus was on developing resource assessments that account for Article II principles and achieve consensus in decision-making (Constable 2000). In 1990 the Commission endorsed the objectives for harvesting the krill resource (Constable 2000; 780):

- *To keep krill biomass at a level higher than would be the case for single species harvesting considerations and, in so doing, to ensure sufficient escapement of krill to meet the reasonable requirements of predators;*
- *Given that krill dynamics have a stochastic component, to focus on the average biomass that might occur over a future period than on the average biomass at the end of that period, as might be the case in a single species context;*
- *To ensure that reduction of food to predators which may arise out of krill harvesting is not such that land-breeding predators with restricted foraging ranges are disproportionately affected compared with predators in pelagic habitats.*

The Krill Yield Model (KLM) was based on an earlier method (Beddington 1983) and adapted to the krill fishery (Butterworth 1992). The KLM derives an estimate of the potential annual sustainable yield of krill stocks (Butterworth 1992; Constable 2000). The yield is determined by a proportion (termed γ) of an estimate of the pre-exploitation biomass (B_0) (Constable 2000; Kock 2000; Parkes 2000). The krill harvest objectives form the basis of specific decision rules for determining the value of γ. The decision rules state (Kock 2000; Parkes 2000):

[160] See CCAMLR 1980; Powell 1989; CCAMLR 2002.

1. Choose $\gamma 1$ so that the probability of the spawning biomass dropping below 20% of its pre-exploitation median level over a 20 year harvesting period is 10%;
2. Choose $\gamma 2$ so that the median escapement in the spawning biomass over a 20 year period is 75% of the pre-exploitation median level;
3. Select the lower of $\gamma 1$ or $\gamma 2$ as the level of γ for the calculation of yield.

These decision rules meet the principle set by Article II of the Convention. The first part of the rule is based on the target species and is linked to the requirement for stable recruitment in Article II (3a). It satisfies a risk criterion that even under harvesting, the probability of the spawning biomass falling below a level at which recruitment might be impaired is small (i.e. 10%). This rule will need to be revised as scientific information regarding life history and recruitment dynamics of the krill stock are obtained (Hewitt 2000; Kock 2000). The second decision rule focuses on the maintenance of ecological relationships between predators and prey, as set in Article II (3b). It limits the effects of harvesting on krill-based predators by setting a target of 75% median escapement (Constable 2000). This level is a compromise figure based on the assumption that in single species fisheries, 50% is an acceptable level of escapement, and for predators, no fishing is preferred (i.e. 100% escapement) (Butterworth 1992). Once criteria 1 and 2 have been calculated, the third part of the decision rule results in the lower of the two yields (or levels of harvest) being selected. Choosing the lowest yield means that both criteria in the decision rule can be fulfilled. If the higher yield value were chosen, it would fail to fulfil or put in risk the other criteria (Constable 2000). The KYM has been generalised to apply also to finfish stocks (Parkes 2000; CCAMLR 2001B). The model, called the Generalised Yield Model (GYM) has been applied to several finfish species such as the Patagonian toothfish, lanternfish and mackerel icefish (Constable 2000).

A feature of the precautionary approach within CCAMLR has been the consideration and development of new and exploratory fisheries. CCAMLR recognises that fisheries should be managed from the outset, and during the course of their development (CCAMLR 2001). The Commission sets conservation measures for any Member planning to initiate a fishery for any species, or in any area, that has not previously been exploited (Parkes 2000). CCAMLR employs a ‘progressive expansion’ approach, not allowing new fisheries to develop faster than the information required to manage them can be gathered (Kock 2000). In recent years CCAMLR has seen the rapid expansion of new and exploratory fisheries, especially for the lucrative *Dissostichus spp*; popularly known as Toothfish.

CCAMLR employs a sophisticated process of data collection to manage fisheries. Data is collected for target, associated and dependent species from Members fishing in the Convention Area, scientific observers on vessels, and independent scientific surveys carried out by research vessels. This embodies the precautionary approach by ensuring a wide collection of data by fishery dependent and independent means (Kock 2000; CCAMLR 2001B).

CCAMLR employs a number of measures that can be considered under the ecosystem approach. The CEMP program is the primary approach taken to provide ecosystem information for management (Figure 54 above). CEMP is reviewed in the next section. However a number of other measures apply within CCAMLR that represent ecosystem approaches.

The incidental catch of seabirds by longline fisheries is a significant challenge for CCAMLR. Estimates from the Scientific Committee (CCAMLR, 2001b) of seabird mortality in the IUU fishery between 1997-2000 is in the order of 21,900-68,000 albatrosses, 5000-11,000 giant petrels, and 79,000-178,000 white-chinned petrels, resulting in severe population impacts (ISOFISH 1999). Longlines were introduced in the early 1990's in the *Dissostichus spp*. fisheries around South Georgia (Kock 2000). In recent years longline fisheries have expanded to other fishing grounds, many of which are near sub-Antarctic islands with breeding colonies of albatrosses and petrels or are within the foraging ranges (CCAMLR 2001b). CCAMLR has introduced a series of conservation measures aimed to reduce and document seabird bycatch through a working group on Incidental Seabird Mortality in Longline Fisheries (WG-IMALF). The conservation measures established by CCAMLR have prescribed measures that include longlines being set at night, ship lighting is kept minimal, offal is not thrown overboard during setting and streamer lines are deployed to minimise the interactions between foraging seabirds and longlines (Kock 1992).

The bycatch of non-target species in trawl fisheries is also a management issue. In the mid-1980s several bycatch fish species around South Georgia and the South Orkney Islands were unintentionally overfished from trawl fisheries (Kock 1999). Species that are taken as bycatch in trawls include skates and rays, rat-tails, grenadier, cod, and icefish (SC-CCAMLR 2001) Under the ecosystem approach employed by CCAMLR non-target species must be taken into account in management. The approach developed by CCAMLR has been to set by-catch limits for each species in each statistical area, and reduce localised effects on populations[161] (Constable 2000).

The current challenge to CCAMLR that places the effectiveness of the convention at risk is the impact of illegal, unregulated, and unreported (IUU) fishing. Over the past decade, a critical situation has arisen with the advent of substantial IUU fishing in the Convention area by vessels that are flagged in non-member states[162], or are operating in breach of CCAMLR obligations despite status as a member state (Lugten 1997; Willock 2002). IUU is the most significant and serious challenge to date for the effectiveness of CCAMLR's management of the marine environment (ISOFISH 1999; Agnew 2000).

The scale of IUU fishing for *Dissostichus eleginoides* (Patagonian Toothfish) is several times above the legal fishing limits (Willock 2002). CCAMLR has been unable to control the 'gold rush' for toothfish, though responsibility for this control lies somewhat outside of CCAMLR jurisdiction. IUU fishing for toothfish started around 1993 in the convention area with inspectors noticing a high level of conservation measure infringements (Agnew 2000). IUU fishing has followed an eastward expansion from South Georgia and the peninsula, through to Prince Edward, Marion and Crozet Islands and to Kerguelen and Heard and McDonald Islands. A combination of enforcement measures and declining catches, as the stock is progressively overfished has contributed to this eastward expansion. (Parkes 2000) notes that in 1996/1997, based on landings data, the IUU catch was reported as between 74,000 and 82,200 tonnes. This compares with the CCAMLR regulated catch of 10, 626 tonnes. The value of the unreported catch was in the vicinity of US$275 million (Parkes 2000; Willock 2002). Despite CCAMLR efforts to curb IUU fishing and declining catches, IUU is still a prevalent and threatening issue. reports that in the 2000/01 split year CCAMLR reported catches were 13,271 tonnes versus an IUU catch of 7,599 tones. In addition 30,151 tonnes of toothfish were reported as caught outside the CCAMLR area. (S-C CCAMLR 2001) notes that a significant proportion of this catch is likely to have originated inside the CCAMLR area with reanalysis boosting the IUU catch inside the CCAMLR region to approximately 17,000 tonnes (SC-CCAMLR 2001). IUU fishing in the convention area is thought to be underreported (Lugten 1997).

CCAMLR suffers from the inherent weakness of international organisations where success relates to cooperation between the member governments and recognition of measures by non-members. The pressures of IUU in the CCAMLR region have shown that the wider international

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[161] A fishery may potentially be closed when it reaches the TAC level for the by-catch of a particular species, even if the TAC for the target species has not been reached.
[162] The use of Flags of Convenience is a serious threat to the management of regional fisheries resources. Several States, including Belize, Panama, Bolivia, Canary Islands and Seychelles are open for ships to fly their flag and escape conservation requirements and regulation by not being a member of the international treaty.

context of fisheries must be addressed for the successful management and conservation of Southern Ocean resources. This is particularly acute in the case of trade of harvested species, where nations not party to CCAMLR participate in the harvesting, transhipment, processing and export / import of toothfish species (ISOFISH 1999; Willock 2002). The establishment of the CCAMLR Catch Documentation Scheme aims to address some of these concerns by monitoring the trade in toothfish. The CDS is designed to address the problem of IUU fishing in CCAMLR waters by tracking the origin of catches of toothfish and their movement through international trade (Agnew 2000). Implementation of the CDS across the range of fishing, port, processing and market States, as well as reducing the susceptibility of the CDS to fraudulent activity is a current focus of CCAMLR activity (Agnew 2000).

7.5 Sustainability Indicator Systems within CCAMLR

CCAMLR has developed a variety of measures to implement precautionary and ecosystem-based objectives. CCAMLR has the responsibility for managing several fisheries across a large marine ecosystem. The toothfish fishery extends throughout the Antarctic region and the krill fishery has the potential to become the largest global fishery (Nicol 1999; Constable 2000). The challenges for the development of ecosystem-based management approaches, and the information needed as the basis of these programs has been a significant task, especially through international consensus based decision-making.

Ecosystem research has been an important focus of CCAMLR since its inception and mandate under Article II. It has established an ecosystem-monitoring program to provide accurate scientific information on the relationships between target, associated and dependent species. The CCAMLR Ecosystem Monitoring Program (CEMP) is focused on the krill fishery, and is the basis of developing a management system with decision rules that take into account the dynamics of the krill stock, the relationships within the ecosystem and the impact of harvesting. CEMP can be considered the information basis for a sustainability indicator system. Current work within CCAMLR is investigating how the CEMP information can be further utilised in management with the use of objectives, reference points, and indicators for management feedback. The combined CEMP and its developmental management framework is the basis for the case study below.

7.5.1 Relevance of the Case Study to the Thesis

This case study is directly relevant to the aims and objectives of this thesis. The CEMP program and developmental management measures fit the SIS model and can be scored under the assessment framework. While Article 2 of CCAMLR represents the strategic objective for the SIS, CEMP and the proposed initiatives aim for practical implementation of Article 2. CEMP was one of the first known attempts to generate ecosystem level information and precautionary tools for fisheries at the regional scale in addition to identifying traditional objectives for fisheries management.

7.6 Case 9: CCAMLR Ecosystem Monitoring Program (CEMP).

7.6.1 Background

The CCAMLR convention is unique in the fact that through Article II, not only is conservation of the target resource a primary objective, it aims to ensure that the negative impacts of harvesting do not affect associated and dependent species (Nicol 1991). Hence CEMP takes an ecological focus but does not directly account for broader socio-economic factors, though these factors are a pressure within the fishery.

(Miller 2002) describes how the objectives set by Article II could be achieved by the following approaches:

i. Harvested populations should be assessed and monitored;
ii. Ecological interactions between harvested and other species, either dependent on, or related to them, should be defined and quantified; and
iii. Levels of depletion should be estimated in order to monitor effectively the restoration of depleted populations.

To address the first and last options, CCAMLR established the Working Group on Fish Stock Assessment in 1984 to advise the Scientific Committee and Commission (Miller 2002). The second option issue of an ecosystem approach represented new ground and an unprecedented challenge for CCAMLR (Agnew 1997). Based on previous investigations such as BIOMASS, the Scientific Committee noted in 1984 that considerable uncertainty existed in life-history information on the basic status, structure, population trends and effects on harvesting on the ecosystem (Miller 2002). In addition, no other fisheries convention had implemented an ecosystem approach - CCAMLR had no precedent to follow.

Because of these issues the Scientific Committee agreed on a mechanism to monitor the effects of fishing on the ecosystem (Constable 2000). The CCAMLR Ecosystem Monitoring Program (CEMP) was established in 1985 (SC-CCAMLR 1985). CEMP aimed to:

i. Detect and record significant changes in critical components of the ecosystem to serve as a basis for the conservation of Antarctic marine living resources.
ii. Distinguish between changes due to the harvesting of commercial species and changes due to environmental variability, both physical and biological.

The Scientific Committee in 1984 (SC-CCAMLR 1984) laid the foundations of the CEMP program, based on monitoring selected predator and prey species in the Southern Ocean (Agnew 1997). When CCAMLR was negotiated, the concern was for rapid uncontrolled development of the krill fishery and the subsequent effects of harvesting this species in the krill-centric ecosystem. In preliminary discussions the Scientific Committee (SC-CCAMLR 1984) identified that 'monitoring', to meet the CEMP objectives, would consist of:

- The monitoring of parameters of selected indicator species (those likely to exhibit quantifiable changes in monitored parameters) of seals, seabirds, and whales;
- The monitoring of harvested species (krill, fish and squid) and other species reflecting change, as an aid to understanding the nature and cause of any observed change.

A working group was created to develop methods and standards for ecosystem monitoring and to administer CEMP. The Working Group for the CCAMLR Ecosystem Monitoring Program (WG-CEMP) was established in 1985 (Agnew 1997). WG-CEMP worked closely with other research groups in the Scientific Committee to investigate monitoring methods for an ecosystem approach. The Working Group on Krill (WG-Krill) was formed in 1988 (Miller 2002) to develop methods to monitor the effects of krill fishing on krill stocks directly and to develop within CCAMLR a krill management regime and focus on the development of the krill yield model (Nicol 1991; Miller 2002).

Monitoring the entire Southern Ocean ecosystem was not a viable option, so CCAMLR adopted the notion of indicator species [163] - dependent or related species that were likely to reflect

[163] The discussion on using *indictor species* was one of the first attempts at exploring the notion of using indicators as a tool within fisheries management. Using biological indicators as a measure of fishery health parallels the modern practice of monitoring selected environmental and socio-economic indicators

changes in the availability and status of the krill resource as a result of fishing activity (SC-CCAMLR 1984). The idea of using predators as an *indicator* species gained credence during this time with biological investigations into the relationships between predators and fisheries prey. [164] CCAMLR focused on the idea that predators were good indicators of the status of harvested prey and used this as the basis of the CEMP methods.

7.6.2 Structure and Indicators

CEMP follows the objectives set by Article II of the CCAMLR convention, interpreted as the overriding definition that sets the scope for the indicator system. CEMP does not establish a specific indicator framework, though recent work suggests that CEMP will move towards indicator-based frameworks (SC-CCAMLR 2001; Constable 2002; WGEM 2002). Analysis of CEMP under the assessment framework includes these potential indictor and management procedures.

The CCAMLR ecosystem management approach is described below in Figure 55. The figure highlights two principal structures: the monitoring and the management system. The physical world (or ecosystem) represented by the blue-boxed region, is monitored by CEMP. The target population, environmental parameters, associated and dependent species and catch information are all monitored and form assessments of the status of the ecosystem and the harvested populations. Information on the ecosystem derived from CEMP is fed through to the management system. This system consists of a series of management objectives (based on Article II) and a management procedure consisting primarily of decision rules and an indicator framework. The rules adjust the harvest in response to signals from the ecosystem, and aim to fulfil the broader objectives.

The CCAMLR ecosystem management approach, comprising CEMP and the management system, fits the requirements of the SIS model. Strategic objectives are filtered down to form decision rules based on monitoring selected species from the Southern Ocean ecosystem. The SIS focuses upon ‘indicator species’ that measure the status of the harvested stock and its effects

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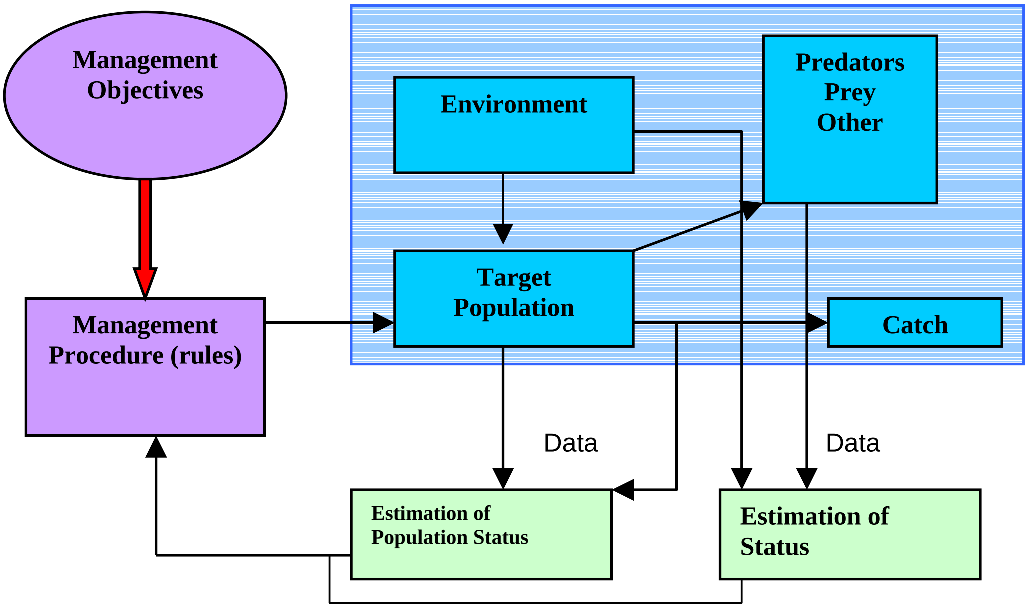
to assess the sustainability of marine capture fisheries. In this instance, predators are monitored as an indicator of target stock health, and fulfil the inherent difficulties associated with monitoring a pelagic, broad ranging species such as krill.

[164] Agnew (2000) notes that in this period, a number of studies were demonstrating that seabirds and marine mammals were reasonably good indicators of prey availability in certain environments. For example, it is noted that brown pelican fledgling rates were good indicators of Californian anchovy stocks (Anderson et al 1980) and breeding success in South African seabirds, including the African Penguin, were influenced by the abundance of fish stocks Crawford & Shelton (1981).

on ecosystem components. The ability of CCAMLR to address the concerns of associated and dependent species is an innovative approach that has evolved over the 20 years of its operation.

Figure 55. CCAMLR approach to ecosystem based management

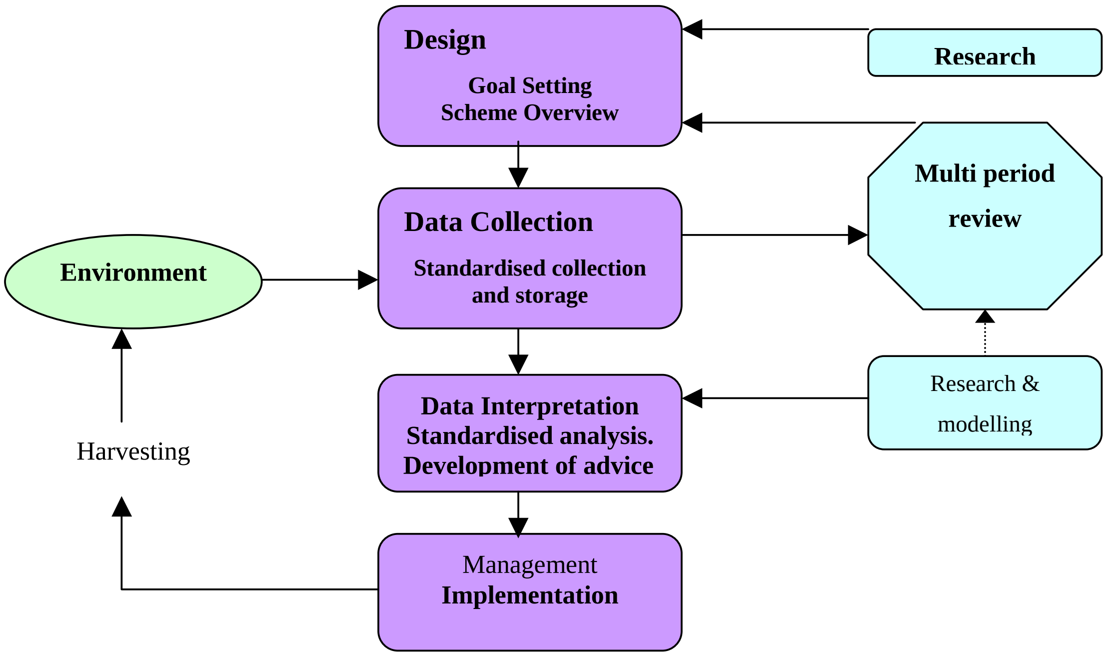


(Adapted from (Constable 2000)).

The CEMP program is the core of the CCAMLR ecosystem-monitoring program (Figure 56 below). CEMP follows a design, data collection, interpretation and management phase with the alteration of harvesting procedures influencing the environment. The design phase involved the assimilation of previous ecosystem research in the Antarctic region, and set the basis for identification of CEMP species and sites. In addition the design phase laid the foundation for interpretation of CEMP information in a management context (Agnew 1997).

CEMP has developed a sophisticated data management approach that takes into account the difficulties inherent in a large-scale scientific program. An important feature is that monitoring information is held in a central system with data input from member States. Data collected during the Antarctic summer season is submitted to the CCAMLR secretariat at the end of the June that immediately follows it (Agnew 1997; Miller 2002). Data from fisheries is submitted three months after the end of the statistical year. As a result the data from predator, prey and the physical ecosystem is available for analysis and interpretation in the six months following the Antarctic summer and before the next CCAMLR meeting (CCAMLR 2001A).

Figure 56. The CEMP monitoring design. (Adapted from (Agnew 1997))



CEMP identifies a number of prey and predator species to be monitored. The prey species are selected for their key positions in Antarctic ecosystems and whose potential harvest would have a major effect on the marine system (Kock 2000). This included two species of Antarctic krill (*Euphasia superba* and *Euphasia crystallorophias*), Antarctic silverfish (*Pleuragramma antarcticum*), and early life stages of several fish species. Predator species were selected according to their potential as indicators of changes in prey availability (Constable 2000). This required that species feed predominantly on the prey species, have a wide geographical distribution, represent important ecosystem components, life history parameters were understood, and baseline data exists for the monitoring program (Agnew 1997; Constable 2000). The present list of monitored species includes: crabeater (*Lobodon carcinophgus*) and Antarctic fur seals (*Arctocephalus gazella)*, chinstrap (*Pygoscelis antarctica*) adelie (*P. adeliae*) gentoo (*P. papua*) and macaroni (*Eudyptes chrysolophus*) penguins, Antarctic (*Fulmarus glacioides*) and cape petrels (*Daption capense*) and black browed albatross (*Diomedea melanophris*) (Constable 2000; CCAMLR 2001a). A number of parameters are monitored for each species that reflect the potential to respond to changes in the availability of prey species or environmental factors. The parameters fall into four categories: reproduction; growth and condition, feeding ecology and behaviour, and abundance and distribution (Agnew 1997).

The challenge for CEMP is the implementation of ecosystem data into pragmatic information that can be used as the basis of decision rules for fisheries management. This concept is the focus of current and future discussion within the Working Group on Ecosystem Monitoring and Management (WG-EMM). Despite the ecosystem being monitored since 1987, there have been no attempts at using this information directly in decision rules (Constable 2000). Current assessments focus on an inspection of trends in the predator parameters coupled with models to explain the trends. Without direct reference to a set of specific objectives and decision rules to implement measures, a lack of consensus could be a possibility within the commission when deciding on harvest restrictions. The WG-EMM has noted that further improvements are required to achieve the objectives of the CEMP program.

(Constable 2002) identifies that CCAMLR needs to adopt a management procedure which maintains ecological relationships and meets the needs of predators. This would incorporate:

- Operational objectives that articulate and describe the target status of relevant aspects of the system;
- Methods of assessing the status of the system;
- Decision rules governing how harvest controls should be adjusted given the difference between the assessment and the objectives, including the development of reference points and;
- Methods for dealing with uncertainty in ecosystem function and achieving scientific consensus.

The WG-EMM is investigating several means of using the CEMP data in management. The development of aggregated indices based on the predator indicators has been investigated by the working group (Constable 2000). Indices must be sensitive to relationships between species, species and the environment, and between the fishery and krill (Constable 2000; SC-CCAMLR 2001). Further work on defining target and limit reference points for the identified parameters and indices remains a research priority that would assist in the creation of decision rules and feedbacks for regulation of harvesting.

The Scientific Committee has considered key issues central to the development of a management procedure. It notes that further analysis is required on data before a method can be applied (SC-CCAMLR 2001). In 1999 the WG-EMM initiated a reappraisal of its approaches to ecosystem assessment and the development of management procedures. The 2001 SC-CCAMLR report (SC-CCAMLR 2001) promoted discussion on future approaches to ecosystem assessment and management and conceptualised a potential decision making process, based on addressing four fundamental questions:

- *Is the availability of krill changing?*
- *Are the populations of dependent species in decline?*
- *How much krill is required by the dependent species?*
- *What is the extent of overlap between krill fishing and foraging by dependent species?*

A draft management procedure establishes objectives, indicators and decision rules within a framework of ecological interactions between krill and predator species (SC-CCAMLR 2001). A series of indicators, based on the questions above, was proposed by (Constable 2002). These preliminary indicators are listed below in Table 25.

These indicators aim to form the basis of a management procedure that regulates harvesting activity and is based on signals from the ecosystem and predator dynamics. The development of an effective procedure requires operational objectives based on target, associated and dependent species relationships, methods for assessing the status of the ecosystem following the monitoring of indicators, and decision rules for setting harvest controls and conservation measures (Constable 2002). This approach follows the SIS model in the form of a set of identified criteria being broken down into operational objectives, indicators, and reference points to achieve the strategic objectives set by Article II. The CCAMLR approach bases the development of indicators on a strong series of inputs from monitoring in CEMP, and generates outputs through decision rules. A future challenge for CCAMLR will be to expand the krill-centric ecosystem based management model to include finfish and squid fisheries, but the task at hand is directly focused on the elaboration of management approaches to ensure the sustainability of a krill based fishery and related ecosystem.

Table 25. CEMP based Objectives, Indicators and Decision Rules.

Procedure 1. Precautionary Catch Limits **Objective***: The median escapement from the fishery of the krill spawning stock should be 75%.* ***Indicator***: Biomass of krill production ***Decision Rule***: Find the long term annual yield as a proportion, γ, of a biomass estimate prior to exploitation, $B_{o,}$ that is highly likely to ensure the level of escapement is achieved ad for which there is a low probability of stock depletion. ***Monitoring***: Single estimate of krill biomass, krill demography. ***Assessment method***: krill population model.
Procedure 2. Target population size for predators ***Objective:*** Abundance of predator populations should not fall below 50% of that prior to harvesting of prey. ***Indicator:*** Biomass of krill population. ***Decision Rule:*** Find the long-term annual yield as a proportion, γ, of a biomass estimate prior to exploitation, $B_{o,}$ that will result in specified predator populations being retained at 50% or more of abundance prior to krill exploitation. ***Monitoring:*** Single estimate of krill biomass, krill and predator demography and feeding relationships. ***Assessment method:*** krill population model.
Procedure 3. Average Fitness of Predators Not Reduced. ***Objective:*** Predator fitness remains unaffected by fishing. ***Indicator:*** Krill density ***Decision rule:*** If local krill density falls below critical level then fishery is closed. ***Monitoring:*** Annual krill density in predator foraging ranges, relationship between predator fitness and density in foraging grounds prior to harvesting. ***Assessment method:*** Statistical model relating to predator fitness and krill density in foraging grounds.
Procedure 4. Maintain predator productivity arising from harvested species. ***Objective*****:** Median predator productivity attributed to the consumption of harvested species to be maintained at or above 80% of its level prior to harvesting. ***Indicator:*** Index of predator productivity. ***Decision rule:*** krill catch adjusted after comparison of predator productivity with baseline and expected outcomes. ***Monitoring***: Parameters necessary for estimating predator productivity attributed to the consumption of harvested species. ***Assessment method:*** initial examination of the properties of productivity indicators and statistical assessment.
Procedure 5. No Interference by fisheries near colonies with land based predators. Objective**:** To eliminate the potential for interference with foraging of land based predators by fisheries. ***Indicator:*** Foraging activity. ***Decision rule:*** Exclude fishery from critical foraging locations and seasons. ***Monitoring:*** Predator abundance and foraging locations. ***Assessment method:*** Evaluation of foraging density to define limits of critical foraging locations.

(Adapted from (Constable 2002)).

7.6.3 Status

CCAMLR has firmly established the development of ecosystem-based management tools for the krill fishery on its future agenda (WGEM 2002). A major component of this work will be the review of the utility of CEMP, to be undertaken in 2003. The review of CEMP will be a significant milestone for CCAMLR with the following aims (WGEM 2002):

- Assessment of the strengths and weaknesses of the existing program and the limitations these might impose for meeting the original objectives;
- Potential additions and improvements to the existing program; and
- Identification of ways of using CEMP data to develop management advice.

In addition, in 2001 the Scientific Committee set a timeline and work plan for the WG-EMM. In 2004, a workshop will focus on the development of ecosystem models including harvested species-environment, predator-prey-environment, and fishery-prey-environment models (SC-CCAMLR 2001). These models will provide a scientific basis for the further development of indicator systems in CCAMLR. The work plan identifies the development of indicator-based approaches for managing the krill fishery a priority, with a dedicated workshop to be held in 2005 (SC-CCAMLR 2001; WGEM 2002). This workshop will address the development of objectives and decision rules, performance measures, and the evaluation of candidate management procedures (SC-CCAMLR 2001).

7.7 Analysis against the Conceptual Framework

Table 26 and Figure 57 highlight the results against the assessment framework. Against Strategic Outcomes (Figure 57a) CEMP obtains a high value for understanding the focus system (3) and a low value for contribution to other dependent systems (1). These scores reflect the ability of CEMP to understand the ecological dynamics of the krill centric ecosystem and simplify its components via indicators for management. CEMP is specifically CCAMLR focused and generally does not contribute directly other reporting systems (but does export ideas to other jurisdictions). An important point to consider is that the information derived from CEMP does contribute to the understanding of the sustainability of fisheries in the Southern Ocean and was the first organisation to develop approaches to ecosystem management.

In terms of the structure of CEMP (Figure 57b) the focus of the indicator system is on the input process (2.7) with the core structure, sub-structure and outputs obtaining average results (1.8, 1.5

and 2 respectively). This result demonstrates the approach that CCAMLR has taken to implement the ecosystem-based management of fisheries. It has developed a complex scientific ecosystem-monitoring program that has been monitored over the last 20 years (represented by the high input score). Only recently has the commission investigated the means to incorporate monitoring information into management information. As a result, CCAMLR is now investigating the use of frameworks, operational objectives, indicators and performance measures (the core and sub-structures) as the basis of decision rules for krill fishery management. Further development of CEMP into a decision-making framework (detailed in Status above) will improve the core structure, sub-structure and output results.

For the System Features component (Figure 57c) CEMP demonstrates high scores in adaptive management and participation (3), above average score for project management (2) and an average score in integrative capacity (1.5). This demonstrates the SIS has an advanced monitoring and feedback process, encourages the participation of decision makers and stakeholders, and is well resourced. An increased score in the System Features component will result from improvements in the integrative capacity within and between dimensions (ecological and economic) and reporting across a wider range of fisheries.

For Fisheries Issues (Figure 57d) the SIS displays maximum scores (3) for ecosystem-based management, fisheries issues, uncertainty, and dynamic reporting. Above average scores (2) are obtained for context sensitivity and relationship to fisheries management while a below average score is obtained for external issues. CEMP maintains a focus on generating information for ecosystem management of krill fisheries that includes monitoring target species and ecological relationships with associated and dependent species. A core aspect of the monitoring is distinguishing the effects of natural variability from human fisheries impacts. CEMP has developed a sophisticated, international approach for monitoring and managing ecosystem data, with the next step to devise a process for this information to be used in management. This step will see the improvements of the fisheries management score. The inclusion of external influences into the monitoring system is not likely in the near future.

Table 26.Scoring for Case 9

Case 9. Commission for the Consevation of Antarctic Marine Living Resources (CCAMLR)				
Strategic Objective	***Sub Objective***	***Operational Objective***	***Score***	***Notes***
1. Strategic				
	Understanding the focus system	*System state and viability*	3	Aimed at understanding the Southern Ocean ecosystem
	Contribution towards other dependant systems	*System contribution to broader societal sustainability.*	1	CCAMLR focused. Some export to other forums.
2. System Processes				
	Core Structure	*Interpretation and definition of sustainability.*	3	Core definition on the basis of Article 2 of the CCAMLR convention.
		Framework classification.	1	Framework for ordering indicators under discussion in CCAMLR.Based on EBM approach Fig 54, 55
		Dimensions of sustainability.	1	Focus on biological and ecological considerations.
		Criteria and sub-criteria.	2	Criteria distilled from definition through SC to establsih objectives and decision rules.
	Core Sub-structure	*Objectives*	2	CCAMLR SC has established objectives for CEMP. Specific indicator objectives are under review.
		Indicators: Scientific	2	Ongoing research into indicstors. Use of proxies. Table 25
		Indicators: Functional	1	Challenge in interpreting CEMP informtion into decision rules. Ongoing R&D.
		Performance values	1	Basic performance measures exist with strong commitment to developing reference points.
	Input processes	*Policy context*	3	Based on CCAMLR rationale of ecosystem management and CEMP objectives.
		Indicator feedback	3	Current focus of science within WG-EMM. Review of CEMP 2003 and SIS set in 2005.
		Stakeholder / user feedback	2	Periodic feedback from CCAMLR Scientific Committee and stakeholders.
	Output Processes	*Visualisation & presentation.*	1	Basic use of visualisation techniques.
		Communication & reporting	3	Reporting on methods regular and available. www.ccamlr.org
		Aggregation and indices	2	Investigation on the use of indicies of CEMP data.
		Decision making influence	2	Evolving influence with intent to set conservation measures to regulate harvesting.
3. System Features				
	Integrative Capacity	*Interaction of sustainability dimensions.*	1	Biological and ecological focus. Does investigate complex ecological interactions.
		Integration with other reporting systems and sectors.	2	SIS reports across fisheries. Export of ideas to other relevant fora and internal reporting.
	Adaptive management	*Social indicator development.*		n/a
		Institutional indicator develop.		n/a
		System monitoring and feedback.	3	Monitoring and feedback through SC. National programs collect data, CCAMLR repository.
	Participation	*Participation of stakeholders*	2	NGO and industry involved in SC and Commission level.
		Participation of decision makers and relevant institutions.	3	National governments involved at SC and Commission level.
	Project Management	*Institutional Capacity*	3	Well resourced.
		Marketing and R&D	2	CEMP program promoted to other organisations as example of EBM.
4. Fisheries Issues				
	Incorporates Ecosystem Mgt Principles	*SIS reflect broader ecosystem based management principles.*	3	First known attempt at EBM in a fishery context. Pioneered ecosystem considerations.
	Target Species info	*Indicators assess state of the target stock , used in management plans.*	3	Focus on krill centric system.
	Recognises precaution	*Assessments explicitly recognise all forms of uncertainty.*	3	CCAMLR and CEMP have established quantitative approaches to considring uncertainty.
	Identified relationship to fisheries management.	*Indicators feedback to mgt.*	2	Proposed SIS feeds into decision rules.
	Static vs. dynamic.	*Static and dynamic reporting within SIS.*	3	Dynamic approach with regular scientific update of stocks, associated species & ecosystem info.
	Context sensitive.	*Does the SIS take specific fishery context isues into account?*	2	Proposed measuresfor fine scale catch and effort reporting to link into CEMP.
	External Influences.	*Informmation on overcapacity, subsidies, trade, fleet structure, IUU fishing and external influences.*	1	CDS scheme may feed into the CEMP SIS for information on trade and IUU. Not presently linked.

Figure 57(a-e) Orientation graphs for Case 9

Figure 57a Strategic Outcomes

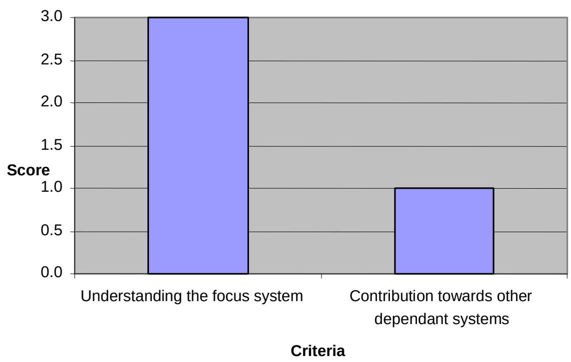


Figure 57b System Process

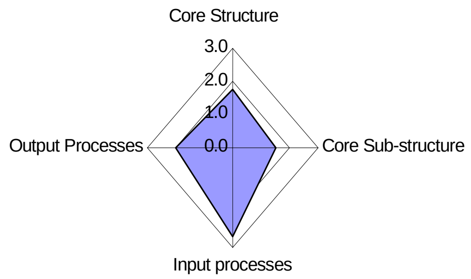


Figure 57c System Features

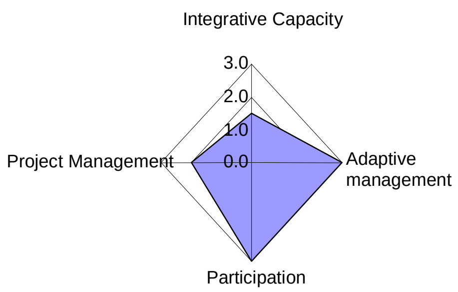


Figure 57d Fisheries Issues

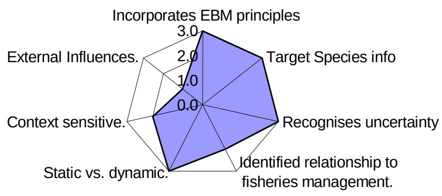
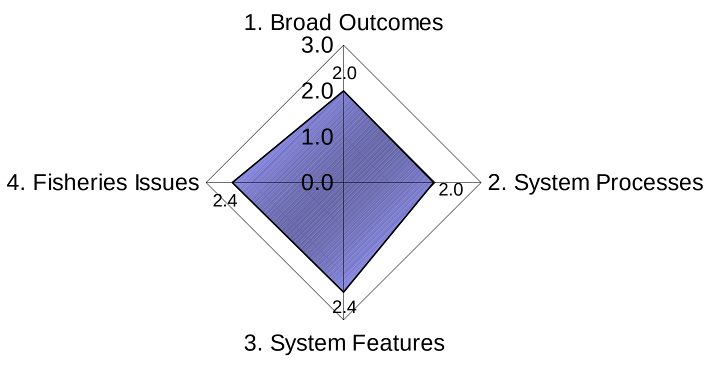


Figure 57e Case 9 Aggregate



The Case Aggregate (Figure 57e) highlights an overall above average scoring system with the focus towards fisheries issues (2.4) and system features (2.4). As CEMP moves towards the development of an indicator system and decision rules, the score would be expected to increase in the System Process component. When discussing the merits of the CCAMLR approach, it must be noted that the CEMP system has developed within a climate of international cooperation and consensus decision-making - the system is as effective as the commitment and cooperation of its members. The threat of IUU fishing undermines the ability of CCAMLR to manage, though IUU is primarily focused on the finfish fisheries at this present time. CCAMLR, through the CEMP program, has established a forward looking and innovative assessment program that converts ecosystem information into decision rules and move towards the sustainable development of regional fisheries.

7.8 Conclusion

CCAMLR was one of the first fisheries management organisations to conceptualise the ecosystem approach in the management of fisheries. This is due to the unique nature of the Convention to focus its activity not only on fisheries management but conservation in an ecosystem context, expressed as a set of objectives within Article II. In the 1980s CCAMLR moved toward the creation of a monitoring program in the form of CEMP to account for the ecosystem effects of krill fisheries. This program set the foundations of an ecosystem management approach within CCAMLR - a significant challenge in terms of a consensus based international organisation.

The CCAMLR SIS has been identified as consisting of CEMP and an emerging decision-rule based management approach for the krill fishery. The further development and implementation of this approach from a predominantly monitoring based system to a management system raises many challenges within CCAMLR, and one that will be a focus over the next few years within the Scientific Committee. The challenge will be to agree on specific binding decision rules based on sound data and the adoption of the system by consensus in the Commission. If successful, the SIS would provide valuable experience for adoption in other regional conventions that traditionally rely on single target species approach.

Chapter 8: Non-Government Approaches
Case Study: Marine Stewardship Council

8.1 Introduction

The advent of civil society interests into traditional fisheries management has been an emerging process since UNCED in 1992. In particular, non-government environmental organisations (NGOs) have emerged as significant players in fisheries management debates. NGO involvement in fisheries management has stemmed from increasing community concern over the management of fish stocks and the potential crisis from global over-fishing of stocks. Events such the collapse of the Chilean Anchovy and Canadian Grand Banks cod fishery has added to public concern over the future directions of fisheries management. NGO organisations play an important role in the fisheries management process, acting as an independent observer one step removed from commercial interest and government policy. The role of the NGO with a conservation interest has in the past received a mixed response from commercial operators and government regulators, with the degree of involvement in direct decision-making relating to the status of the organisation with decision makers. NGOs also facilitate public support and focus pressure on fisheries decision bodies. Community concern over fisheries issues can translate into direct involvement by member driven NGOs, subsequently some of the most successful fisheries outcomes have been when industry, decision makers, and NGOs have cooperated together on issues.

The role of NGOs in fisheries management has radically altered over recent years. Aside from traditional environmental advocacy and placing political pressure on decision makers toward conservation outcomes, NGOs are increasingly involved in management consultation and decision making as a part of the co-management of resources. NGOs are establishing partnerships with stakeholders in the total fisheries production cycle: from fishers to processors, wholesalers, retailers and consumers. The establishment of eco-labelling schemes such as that of the Marine Stewardship Council (MSC) represents the evolving role of the NGO as an important stakeholder in management (Constanza 1998). The use of indicator systems by NGOs offers a means of establishing independent review of fisheries management systems and increasing support for management measures. Indicator systems provide a means by which NGOs (and the public) can become directly involved in the management cycle. The MSC initiative has developed a system to facilitate an eco-labelling initiative that promotes sustainable fisheries to consumers.

8.2 Introduction to the MSC

The MSC is an independent, not-for-profit, international organisation dedicated to promoting the development of sustainable fisheries and best practice management (MSC 2000a). It has established a program of assessment, certification and promotion of ‘sustainable’ fisheries and focuses on a market-based approach to complement regulatory systems. The MSC is a voluntary program open to all wild capture fisheries across the world whatever their size, scale, type, or location (MSC 2000a). It attempts to change the incentive structure through a market-based approach so that fishers, processors, retailers and consumers who are certified gain economic and social benefits. Through certification against a standard for sustainable fisheries, and subsequent award of a licensed product label, consumers are able to distinguish between products from recognised sustainable sources. A key challenge within the MSC is the creation of suitable markets and ongoing consumer interest to ensure that the incentive remains for ongoing commercial involvement.

The core of the MSC operation is the development and promotion of an international standard that identifies fisheries that are harvested in accordance with responsible, environmentally appropriate, socially beneficial and economically viable practices (Mfodwo 1998; MSC 2002). This standard is based on the FAO Code of Conduct for Responsible Fisheries and intends to complement approaches from international organisations like FAO (MSC 1998b). The MSC Principles and Criteria for Sustainable Fishing forms the basis of the indicator system (MSC 1998b). The standard is applied to a fishery through an independent certification process, and a label awarded to the product. The MSC then aims to harnesses consumer power by identifying sustainable seafood products through this label. An important consideration in use of the logo is that the product, certified as originating from a sustainable fishery, can be traced through its production history. A company wishing to use MSC products must undergo a ‘Chain of Custody certification’, which guarantees the traceability of the labelled product (MSC 2001b). A chain of custody certification and license agreement complements the fishery certification and adopts a ‘fishery to plate’ process.

The MSC was created in 1996, the product of a partnership between World Wide Fund for Nature (WWF) and the multinational company, Unilever. This partnership set a precedent and important example for business and NGO cooperation on sustainability (Fowler 1998). The MSC now operates independently and sources its own funding from a wide range of charitable foundations, private companies and individuals (MSC 2000a; MSC 2001c).

The MSC has a defined set of aims that enables the organisation to participate as an independent stakeholder in the sustainable fisheries debate (MSC 2001c). They include:

- Creating a standard for sustainable fishing trough the Principles and Criteria;
- Provide a voluntary certification and eco-labelling framework supported by commercial entities in fisheries;
- Accrediting and monitoring certifiers to undertake assessments;
- Rewarding products with the MSC logo;
- Promoting the label to consumers to buy certified products;
- Establishing consultative and governance procedures to improve the scheme.

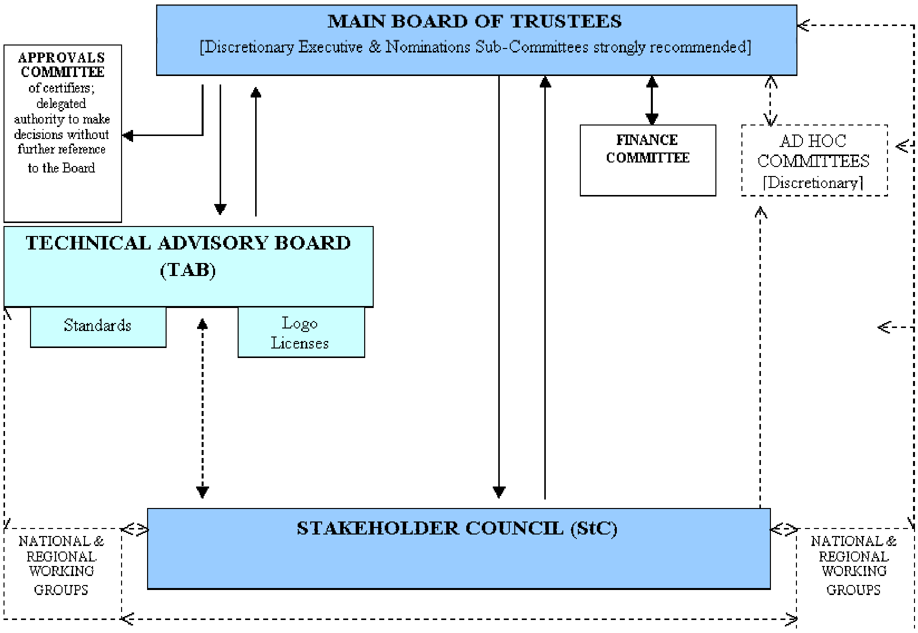
8.3 Governance Framework for the MSC

The MSC was created in 1996 by a partnership between WWF and Unilever PLC. In 1999 the MSC become an independent entity, with its own sources of funding and a complex governance structure.

The initial partnership between WWF and Unilever has raised interest in academic and corporate circles. (Fowler 1998) notes that this partnership was established on a shared objective: the long-term viability of fish stocks. The motivation however, for each partner was quite different in establishing the MSC and pursing the common objective. Unilever is one of the world's largest consumer products conglomerates with control over 20% of the European and US frozen fish markets and global sales of just under 600 million pounds sterling (Mfodwo 1998). Unilever controls approximately 10% of the world fish-oil market for use in cosmetics, detergents and pharmaceuticals (Mfodwo 1998). Through the MSC, Unilever hope to source all its fish products from MSC certified fisheries by 2005 (Fowler 1998). This translates to a strategic repositioning of the company towards a 'greener image' in response to consumer demands and a growing trend of companies to purchase from 'green' suppliers. This enables Unilever to present itself as an organisation that incorporates sustainability principles in practice, while simultaneously safeguarding a core component its business capital, fish stocks. WWF is a global independent conservation organisation with more than 5 million members (IUCN 1998). It is a science-based organisation that creates and implements policy relating to environmental protection and resource conservation (IUCN 1998; WWF 1999). (Mfodwo 1998) notes that WWF is considered by analysts to be ‘respectable’ or even conservative in terms of global NGOs. WWF has had several policy successes in the past; including the Southern Ocean whale sanctuary, migratory species, wildlife trade, and the inclusion of strong conservation language in the UN Fish Stocks Agreement (IUCN 1998; Mfodwo 1998). The MSC initiative fits into the objectives of the WWF Endangered Seas campaign that aims to specifically address the issue of declining global fish stocks. The campaign calls for the creation of new socio-economic incentives for sustainable fisheries (IUCN 1998). The MSC initiative represents an approach to achieve this goal within the boundaries of the WWF mandate on ecosystem-based management.

The creation of the MSC met with some initial scepticism from fisheries managers (particularly outside Europe), the fisheries sector, and environmental organisations other than WWF (Potts 2001). This was largely founded on the perception that the MSC was established without a sufficiently open process of consultation involving all stakeholders. Critics focused on the process of developing the principles and criteria that form the basis of certification. Another concern was the role of an international NGO in evaluating government management systems that are normally established through processes that are more democratic (Mfodwo 2000). Concerns also existed that Unilever, with its commitment to buy only MSC-certified fish by 2005, could ‘water-down’ certification standards to maintain supply. Despite these concerns, the MSC has continued to grow and attract increasing support from industry, governments and NGOs. A recent review of the MSC governance structure in June 2001 was conducted to address the changing needs of a rapidly evolving organisation and intended to provide a more efficient and transparent decision-making process in response to identified concerns by stakeholders (MSC 2001b; MSC 2002). The framework for the governance of the MSC is highlighted in Figure 58.

Figure 58. The MSC Governance Structure



Adapted from MSC (2002).

The MSC is governed by a series of executive and delegated bodies to achieve the outcomes of promoting the MSC Standard, appointing independent certifiers, and licensing the use of the logo (MSC 2000b; MSC 2002). The governance structure was implemented after 10 months of review. The Board of Trustees is the executive decision making body within the MSC, involved in decision-making and the high-profile advocacy of the MSC and its objectives. The Main Board of Trustees represents the final decision-making authority in terms of the MSC technical, scientific and quasi-judicial functions, and is advised by the expert-based Technical Advisory Board (MSC 2002). The Board includes the chairman of the Technical Advisory Board and the two joint chairmen of the Stakeholder Council.

The Technical Advisory Board (TAB) has 15 members and replaced the former Standards Council. The TAB advises the Board of Trustees on all relevant matters including the setting and review of the MSC Standard, logo licenses and Chain of Custody certification (MSC 2002). The TAB is able to form sub-committees to focus expertise on specific topics or functions. The Board of Trustees is responsible for appointing the TAB whilst the TAB is responsible for appointing its own Chair (MSC 2000b; MSC 2002).

The third consultative body is the Stakeholder Council. The Council is a body of 30-50 members made up of a diverse range of stakeholder interests, ranging from conservation, industry, academic, processing and developing nations (MSC 2002). The Council fulfils specific roles and acts as a point of reference, participation, liaison and representation. It has two joint chairmen who sit on the MSC Main Board and are involved in Board matters, decisions and appointments. The Council is able to submit views directly to the Main board (which must take these into account when decision making). The Stakeholder Council represents a balance of MSC stakeholder interests through a defined structure and procedures. Half of the members are appointed by the Board in consultation with the MSC Executive with the remaining half appointed by the Council members (MSC 2002).

The governance mechanisms developed by the MSC have been developed to promote independence and transparency. An external panel undertook this review and implementation in consultation with several hundred interested parties (MSC 2000b; MSC 2002). How these governance mechanisms deliver MSC outcomes in an increasing climate of promotion, certification initiatives, and fisheries sector interest will become apparent in the near future.

8.4 Management of Fisheries and the MSC

The MSC mission is (MSC 2003) :

> *"To safeguard the world's seafood supply by promoting the best environmental choice"*

The MSC does not initiate the direct management of fisheries resources. The MSC takes a fundamentally different approach being an independent non-government organisation. This approach is based on being an independent certifier of the management process and linking this certification to a commercially used logo that influences markets (MSC 2001c). The management of the certification process, the certification standard, and management and promotion of the logo are the main functions of the organisation. It should be noted that the MSC does not undertake the direct process of each fisheries certification. To remain independent, the MSC accredits qualified certification organisations that are experienced in fisheries and certification issues, and trains them in the MSC methodology and the Principles and Criteria (MSC 2001b).

The OECD (Salzman 1991; 38) has defined eco-labelling as:

> *"Voluntary granting of labels by a private or public body in order to inform consumers and thereby promote consumer products which are determined to be environmentally more friendly than other functionally and competitively similar products."*

The concept of certification and eco-labelling as the basis of market based incentives for the improved management of fisheries is of recent origin. Over the last 10 years these approaches have grown in scope and have become increasingly important to consumers. Mfodwo (2000) identifies that certification refers to a focus upon the legal permissibility of the harvest and that the fish has been caught within the regulatory framework of an international or national authority. [165] Certification exists primarily in the realm of regional fisheries agreements where regulatory frameworks and cooperation on trade and management is necessary. Eco-labelling or environmental labelling tends to progress one step further than the certification process (Teisl et al 2002). Issue of a label tends to be granted on the basis of investigation into the ecological integrity of the harvest, including ecosystem considerations within the fishery (IISD 1996; Teisl et al 2002). Usually a performance standard is established as a part of labelling program. After meeting or exceeding the standard a label or logo is awarded to the product that conveys this information to the market. Eco-labelling and certification have a number of strengths that can include promoting consumer choice, improving economic efficiency, and enhancing market development (IISD 1996). Certification encourages organisations to commit to a process of continual improvement and external scrutiny by civil society and government (IISD 1996). Eco-labelling targets the consumer who is encouraged to use buying power as a tool to promote better environmental outcomes (IISD 1996). The MSC scheme has been the most well developed fishery eco-label approach to date but other examples are the 'dolphin safe' tuna labelling processes (Teisl et al 2002).[166]

The concept was endorsed at UNCED in 1992, where governments agreed to "encourage labelling and other environmentally related product related information programs designed to assist consumers to make informed choices" (FAO 2000). This process is often defined as a market-based or 'soft law' instrument that seeks to direct consumers purchasing behaviour to take account of attributes other than price (FAO 2000). The label conveys information about the environmental attributes and status of the product without the buyer having to comprehend the technical aspects of the harvest process. Therefore being labelled (and improving the impacts of the operation) provides a market advantage to the fisher. This theory gives rise to the question –

[165] An example is the CCAMLR catch documentation scheme or the ICCAT certification scheme.
[166] Teisl et al (2002) presents a comprehensive account of the 'dolphin safe' tuna labelling issues in the early 1990s and the results of research that suggest that labelling does affect consumer spending patterns.

would consumers choose a labelled product and potentially pay a higher price for a product that carried an eco-label?

The role of the consumer within the labelling process is an essential one and directly relates to the viability of the scheme. The consumer ability to distinguish and buy a labelled product will depend on their capacity to address and respond to environmental concerns (FAO 2000). Consumer trust, awareness and confidence in the labelling scheme are vital for success. If the market becomes saturated with competing schemes, the consumer is likely to return to non-labelled brands or not distinguish a superior labelling scheme from an inferior scheme. Therefore promotion of the label to consumers, the development of an open and transparent standard, and the development of incentives for the fisheries sector to seek certification are essential components of a successful scheme (IISD 1996; FAO 2000).

Although the implementation of eco-labelling is increasing in fisheries systems, research suggests the benefits of labelling schemes to fisheries management and the fisheries sector are generally limited (FAO 2000). However a recent study by (Teisl et al 2002), noted that in the dolphin friendly canned tuna labelling scheme, evidence exists that the labels affect consumer behaviour, consumers respond to labelled products, and the dolphin-safe label increased the market share of canned tuna. The empirical evidence suggests at this point in time the MSC program is increasing in popularity by consumers and is creating incentives for the fishing sector to become involved. Several large scale and lucrative fisheries have been awarded the MSC logo, and have demonstrated a capacity to benefit from the scheme in an economic, political, and environmental context (MSC 2001b; MSC 2003).

The eco-labelling presents significant trade issues. Approximately 37 percent of global fisheries production enters international trade and represents significant export earnings for developing nations (FAO 2000). The development of labelling programs could potentially act as a mechanism to improve management practices and a potential barrier to trade. (IISD 1996) notes that if eco-labelling programs constitute a voluntary mechanism, and not by governments to define acceptability, then they are outside the influence of the World Trade Organisation (IISD 1996). However if eco-labelling programs are defined as a market entry requirement they may be the subject of a WTO challenge. The increasing nature of global trade in fisheries products, and the fact that significant trade flows from developing to developed countries represent future challenges to labelling programs.

8.5 Sustainability Indicator Systems within the MSC

The MSC developed an environmental standard for sustainable fishing, the 'MSC Principles and Criteria', through an extensive international consultation process. A fishery may be assessed against these indicators in order to be certified as a 'sustainable' fishery (MSC 1998b). The fishery undergoes an assessment against the standard and is awarded the logo if passed. Once certified, companies wishing to use the MSC products undergo a 'chain of custody' certification that guarantees the traceability of the labelled product from the fishery to the consumer (MSC 2001b).

The MSC 'Principles and Criteria' form the basis a set of indicators against which a fishery may be assessed (MSC 1998b). This indicator system is adapted to each particular to each fishery undergoing assessment. The SIS and the method used to link it to the eco-label are detailed below.

8.5.1 Relevance of the Case Study to the Thesis

The SIS employed by the MSC directly relates to the generic SIS model. Structure follows a hierarchical approach, with a core system consisting of an overarching definition or principle, a series of criteria, sub-criteria, indicators, and performance measures and significant input and output processes that directly feedback to the core system (Chapter 3: Figure 13). The application of the MSC logo represents a significant output from the SIS. This output goes beyond the traditional application of the SIS applied to a fishery. Use of the MSC logo has become an internationally based application of an SIS to fisheries within national jurisdictions and affects consumer spending and markets for fisheries products. This SIS from a non-government organisation represents an innovative application of sustainability indicators in the fisheries sector to improve management outcomes and create market incentives for sustainable fisheries.

8.6 Case 10: The MSC Certification Process

This case study describes the MSC approach to 'sustainable fishery' certification. The MSC has developed a process to assess a fishery via a developed standard, the Principles and Criteria for Sustainable Fishing. The MSC accredits an independent and expert-based certification team to audit a selected fishery against the Principles and Criteria, awarding the use of the MSC logo if the fishery 'passes' the process. Certification teams must meet strict independence and knowledge criteria established by the MSC. The certification only applies to the fishery and harvesting operation itself, up until the catch is landed (MSC 2001b). After this point, any organisation that processes, wholesales or retails the MSC product must also be certified and licensed by the MSC (MSC 2001c). This is termed a ‘chain of custody certification’. Its purpose is to ensure that the certified product can be identified at every stage of its lifecycle, and to ensure that fish products bearing the MSC logo legitimately originate from a certified source (MSC 2001b).

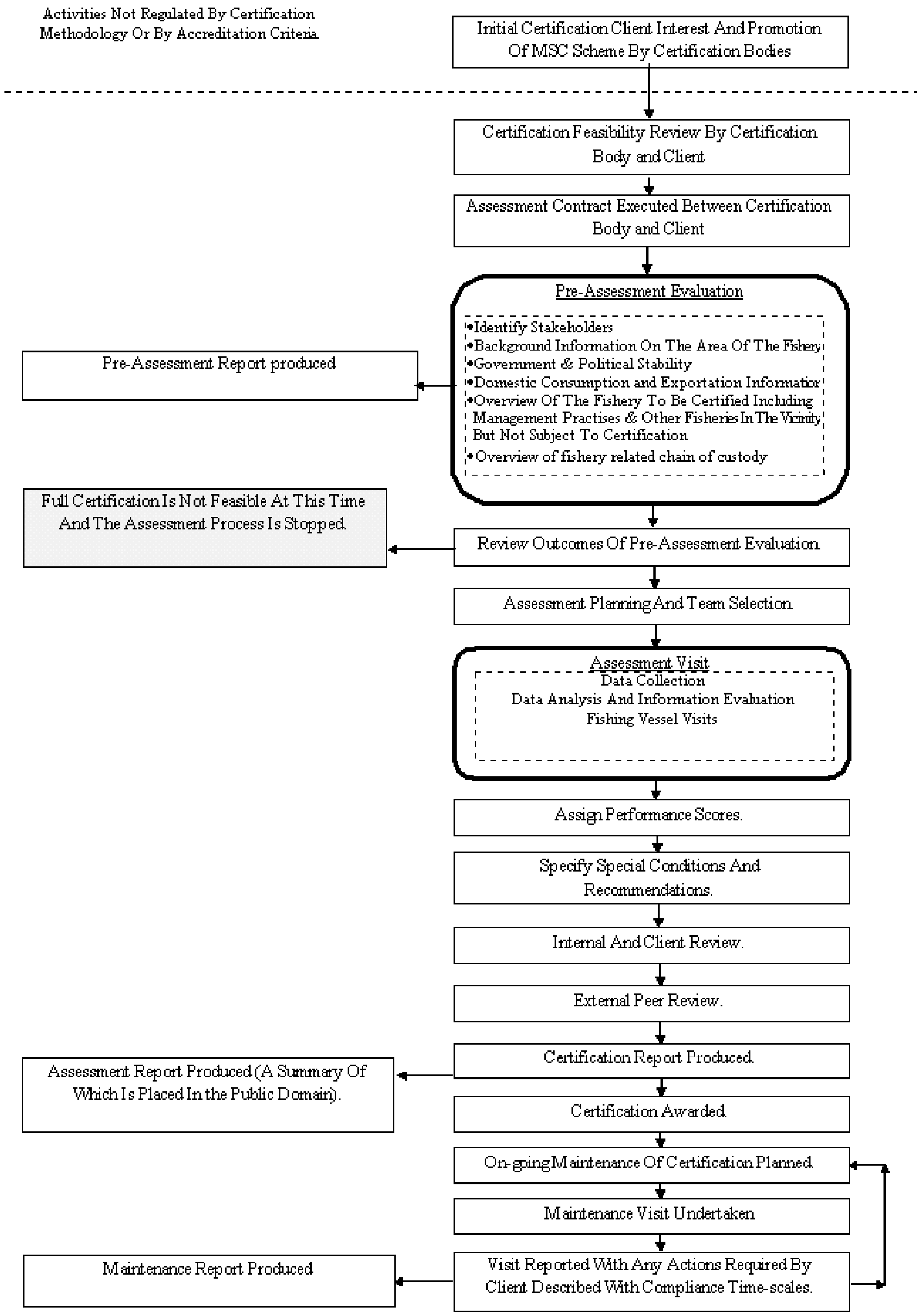
8.6.1 Background

The MSC process to certify candidate fisheries against the Principles and criteria is summarised in Figure 59 below. Fisheries certification stages include identification, pre-assessment, assessment and monitoring. The process is designed to facilitate not only the immediate certification of a fishery, but to ensure that it complies with ongoing certification measures and auditing (MSC 1998b; MSC 2001c). The Principles and Criteria form an integral part of the process and are applied in the assessment phase with through a scoring process.

The MSC supports environmentally appropriate, socially beneficial, and economically viable fisheries. It seeks a balance between these dimensions as set out by sustainable development. It also seeks to encourage the development of national standards for fisheries (MSC 2001c). The certification process seeks to address the following issues (MSC 2001a):

- Establish a consistent methodology to enable all MSC accredited certifiers to operate in a consistent manner;
- Provide a transparent process that is required from an international accreditation body for it to be credible with stakeholders, including governments, fishery managers, certification bodies, suppliers of fish products, NGOs and the public.
- A process that assures long-term continuity and consistency of the delivery of MSC certification;
- Ongoing training of certifiers and improvement of the process.

Figure 59. The MSC Certification Process



Adapted from (MSC 2001a)

The first phase, that of pre-assessment, involves an initial interest by the client in the certification process, a Certification Feasibility Review and Pre-Assessment Evaluation. The review introduces the client to the Principles and Criteria and ensures the process and the objectives are understood (MSC 2001b). This step aims to define the certifiable entity (ie. the fishery) and the relevant unit of certification in a spatial capacity. As with most fisheries SIS, the optimal unit of certification is the operational scale, with the stock as a biologically distinct unit combined with the fishing method, gear and practice (MSC 2001a). For an assessment to occur, information may be required on the biological characteristics of the stock that enable it to be defined as a discreet unit for certification. This is not the case for many fisheries where the limits of the population have not been defined and can raise problems when a particular fishery is certified as sustainable. Defining the certification scale can also have important ramifications for direct influences that occur outside the operational scale of the fishery, eg. IUU fishing, economic and trade pressures.

The Pre-assessment Evaluation is a formal report that aims to understand the fishery in the context of the Principles and Criteria, including the management policy and regulations. The evaluation takes into account the background, political stability, domestic consumption and export considerations, stakeholders, and other fisheries in the region (ASOC 2001). The evaluation makes an initial comparison of the fishery against the Principles and Criteria and a decision over whether certification should proceed. The pre-assessment phase, in the context of the SIS model, can be classified as an input process that establishes, defines, and sets the parameters of the core system, ie. the criteria, sub criteria, indicators, and performance scores.

The next phase is the formal assessment of the fishery against the standard. The assessment team reviews the MSC Standard, translating the Principles and Criteria into a draft set of measurable indicators and performance scores and adapting to the particular fishery. The proposed set of performance indicators is published by the MSC. Following public consultation, the assessment team discusses possible changes from received feedback. The assessment team visits the fishery, consults with stakeholders, and collects data as appropriate. With the information, the assessment team begins the process of scoring the fishery against the performance indicators and scoring guides (detailed below). A draft report is prepared that is sent to the client for review and does not contain the actual performance scores issued by the assessment team. The purpose of the report is to ensure the client has no fundamental disagreement with the general content or the accuracy of the assessment.

Once through the peer review process a final Certification Report and Public Certification Summary are prepared. If the fishery passes the scoring requirements and is determined to meet the Principles and Criteria then it can be certified. Official certification takes place when the summary has been received by the MSC for publication on the website (MSC 2001c). The assessment phase can be considered, in terms of the SIS model, the driver for the core system and core sub system. It is this process that determines the criteria, indicators and scoring guides. The core system generates output processes, in this case the certification and ongoing monitoring requirements. This includes annual auditing by the assessment team to the fishery that check compliance. Certification can be removed if the set conditions are not met (MSC 2001a).

The chain of custody procedure is undertaken to ensure that products certified from the fishery and bearing the MSC label, are in fact produced from certified sources. To achieve this the relevant supply chain will be subject to a chain of custody audit (MSC 2001b). With respect to fish catch and processing, chain-of-custody procedures are implemented at the key points of transfer commencing with extraction from the sea to receipt on board; delivery to the dock quayside, market, wholesalers, processors, retailers and caterers (MSC 2003).

8.6.2 Structure and Indicators

The MSC approach employs a fisheries based, sustainability themed framework encompassing biological, ecological, socio-economic and governance criteria, and a hierarchical subdivision process to organise indicators. The Principles and Criteria represent the core of the assessment process as the standard against which client fisheries are certified (MSC 1998a). The Principles and Criteria intend to build upon and complement the existing work of international organisations and industry best practice. In terms of developing a standard, several fishery management and environmental organisations, have adapted the MSC Principles and Criteria for use in their own assessment programs.[167]

The principles have been designed to encourage cooperation with the fishing sector in implementing sustainable fisheries (MSC 1998b). Another aspect of the Principles and Criteria is the prospect of generic application and equal access to its certification program irrespective of

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[167] For example, Environment Australia, a Commonwealth government environmental management and protection organisation, has adapted the principles and criteria for the Guidelines for Sustainable Fisheries program (Case Study 2).

the scale of the fishing operation. The size, scale, type, location, and intensity of the fishery, the uniqueness of the resources, and the effects on other ecosystems will be considered in every certification (MSC 1999). At the apex of the Principles and Criteria, a series of definitions establish, for the purposes of certification, that a sustainable fishery is conducted in such a way that (MSC 2002):

- It can be continued indefinitely at a reasonable level;
- It maintains and seeks to maximise, ecological health and abundance,
- It maintains the diversity, structure and function of the ecosystem on which it depends as well as the quality of its habitat, minimising the adverse effects that it causes;
- It is managed and operated in a responsible manner, in conformity with local, national and international laws and regulations;
- It maintains present and future economic and social options and benefits;
- It is conducted in a socially and economically fair and responsible manner.

The definitions set the basis for the principles and criteria detailed below in Figure 60. The principles cover target and ecological considerations as well as socio-economic and governance concerns.

Figure 60. The MSC Principles and Criteria.

PRINCIPLE 1:

A fishery must be conducted in a manner that does not lead to over-fishing or depletion of the exploited populations and, for those populations that are depleted the fishery must be conducted in a manner that demonstrably leads to their recovery.

Criteria:

1. The fishery shall be conducted at catch levels that continually maintain the high productivity of the target population(s) and associated ecological community relative to its potential productivity.
2. Where the exploited populations are depleted, the fishery will be executed such that recovery and rebuilding is allowed to occur to a specified level consistent with the precautionary approach and the ability of the populations to produce long-term potential yields within a specified time frame.
3. Fishing is conducted in a manner that does not alter the age or genetic structure or sex composition to a degree that impairs reproductive capacity.

PRINCIPLE 2:

Fishing operations should allow for the maintenance of the structure, productivity, function and diversity of the ecosystem (including habitat and associated dependent and ecologically related species) on which the fishery depends.

Criteria:

1. The fishery is conducted in a way that maintains natural functional relationships among species and should not lead to trophic cascades or ecosystem state changes.
2. The fishery is conducted in a manner that does not threaten biological diversity at the genetic, species or population levels and avoids or minimises mortality of, or injuries to endangered, threatened or protected species.
3. Where exploited populations are depleted, the fishery will be executed such that recovery and rebuilding is allowed to occur to a specified level within specified time frames, consistent with the precautionary approach and considering the ability of the population to produce long-term potential yields.

PRINCIPLE 3:

The fishery is subject to an effective management system that respects local, national and international laws and standards and incorporates institutional and operational frameworks that require use of the resource to be responsible and sustainable.

Management System Criteria:

1. The fishery shall not be conducted under a controversial unilateral exemption to an international agreement.

2. The management system shall:

3. Demonstrate clear long-term objectives consistent with MSC Principles and Criteria and contain a consultative process that is transparent and involves all interested and affected parties so as to consider all relevant information, including local knowledge. The impact of fishery management decisions on all those who depend on the fishery for their livelihoods, including, but not confined to subsistence, artisanal, and fishing-dependent communities shall be addressed as part of this process;

4. Be appropriate to the cultural context, scale and intensity of the fishery – reflecting specific objectives, incorporating operational criteria, containing procedures for implementation and a process for monitoring and evaluating performance and acting on findings;

5. Observe the legal and customary rights and long term interests of people dependent on fishing for food and livelihood, in a manner consistent with ecological sustainability;

6. Incorporates an appropriate mechanism for the resolution of disputes arising within the system;

7. Provide economic and social incentives that contribute to sustainable fishing and shall not operate with subsidies that contribute to unsustainable fishing;

8. Act in a timely and adaptive fashion on the basis of the best available information using a precautionary approach particularly when dealing with scientific uncertainty;

Figure 60 continued. The MSC Principles and Criteria

9. Incorporate a research plan – appropriate to the scale and intensity of the fishery – that addresses the information needs of management and provides for the dissemination of research results to all interested parties in a timely fashion;

10. Require that assessments of the biological status of the resource and impacts of the fishery have been and are periodically conducted;

11. Specify measures and strategies that demonstrably control the degree of exploitation of the resource, including, but not limited to:

12. Setting catch levels that will maintain the target population and ecological community's high productivity relative to its potential productivity, and account for the non-target species (or size, age, sex) captured and landed in association with, or as a consequence of, fishing for target species;

13. Identifying appropriate fishing methods that minimise adverse impacts on habitat, especially in critical or sensitive zones such as spawning and nursery areas;

14. Providing for the recovery and rebuilding of depleted fish populations to specified levels within specified time frames;

15. Mechanisms in place to limit or close fisheries when designated catch limits are reached;

16. Establishing no-take zones where appropriate;

17. Contains appropriate procedures for effective compliance, monitoring, control, surveillance and enforcement which ensure that established limits to exploitation are not exceeded and specifies corrective actions to be taken in the event that they are.

Operational Criteria

Fishing operation shall:

1. Make use of fishing gear and practices designed to avoid the capture of non-target species (and non-target size, age, and/or sex of the target species); minimise mortality of this catch where it cannot be avoided, and reduce discards of what cannot be released alive;

2. Implement appropriate fishing methods designed to minimise adverse impacts on habitat, especially in critical or sensitive zones such as spawning and nursery areas;

3. Not use destructive fishing practices such as fishing with poisons or explosives;

4. Minimise operational waste such as lost fishing gear, oil spills, on-board spoilage of catch, etc.;

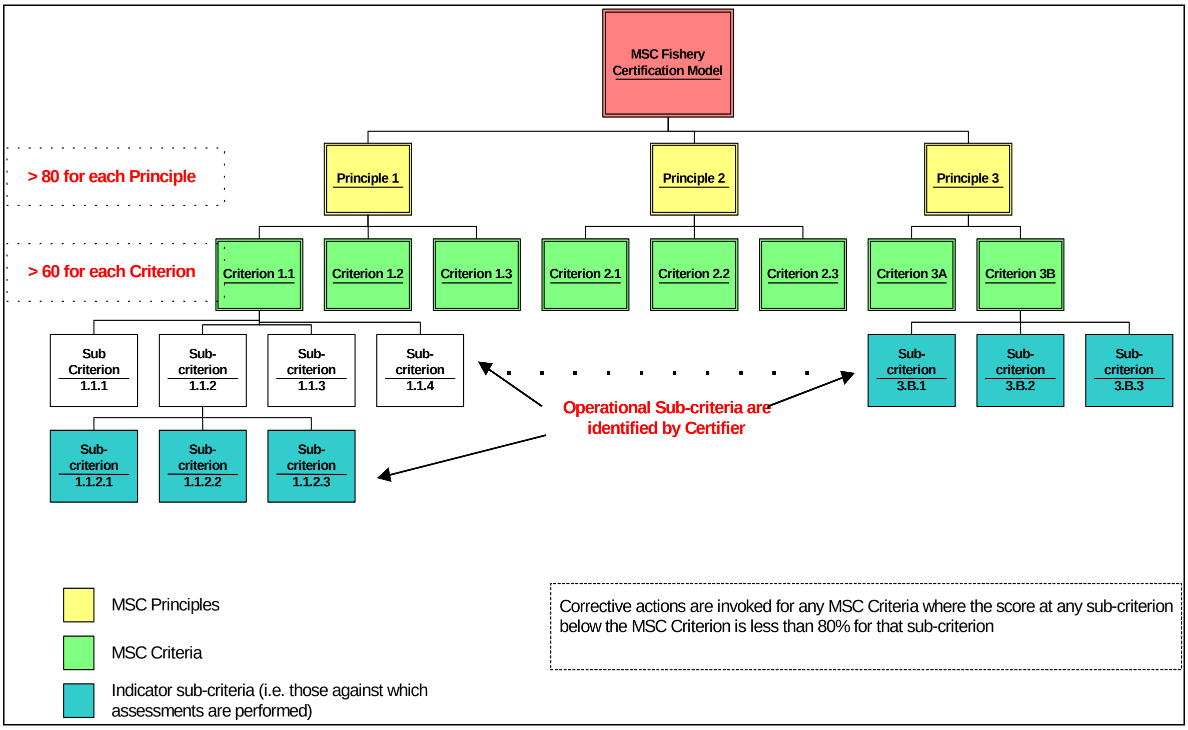
5. Be conducted in compliance with the fishery management system and all legal and administrative requirements; and

6. Assist and co-operate with management authorities in the collection of catch, discard, and other information of importance to effective management of the resources and the fishery.

The MSC Principles and Criteria are a standard applied to a client fishery in order to be certified. This involves a process of translating the generic Principles and Criteria into a set of measurable indicators and performance scores. The process uses hierarchical subdivision to progressively refine the Principles and Criteria into operational sub-criteria, performance indicators and scoring guides (Figure 61). In the figure, a hierarchical set of structures is observed from the strategic to the operational level (MSC 2001d):

- MSC Principles (Generic Principles developed by the MSC);
- MSC Criteria (Generic Principles developed by the MSC);
- Operational Sub-criteria (developed by the certification team as representative of the MSC Criteria for the fishery being certified);
- Indicator Sub-criteria (the lowest level of the hierarchy, and where scoring is conducted; all developed operationally for each fishery);
- Elements (the scoring guide points and weighting for allocating performance scores on each Indicator Sub-criterion).

Figure 61. The MSC subdivision and scoring process



Adapted from MSC (2001d)

Certifiers start with a hierarchy that, for every fishery being assessed, has at the highest level the MSC Principles and Criteria (based on Figure 60). The next stage in the process is to develop operational sub-criteria from each MSC criteria (MSC 2001a; MSC 2001b). The operational sub-criteria are directly relevant to the fishery being assessed and should provide a combined assessment of all the factors required for meeting the higher-level MSC criterion. Under each operational sub-criterion a set of measurable indicator criteria are established against which the fishery is scored. An example below displays the SIS hierarchy with Principles, Criteria, Operational Criteria, Indicators and Performance Measures.

A scoring process is used to assess the fishery against the standard. A method termed Analytic Hierarchy Process has been utilised by the MSC to weight and score the indicator criteria (MSC 2001b). A normalised scale of 0-100 has been chosen for measuring performance. Weighting may be conducted at each level of the 'tree' lower than Principle. Criteria, Sub-criteria and Indicator sub-criteria are all assigned a weighting on a scale from 0-1. The weights reflect the importance of the criteria for the fishery and are developed and justified by the certification team (MSC 2001b).

For each indicator sub-criteria performance scales are selected ranging from 0 to 100. The scales are termed ‘scoring guideposts’ and are submitted for review (see the certification process Figure 51). The MSC must endorse the scoring guides before their use. Performance is based on a 60, 80 or 100 ‘post’. It is important that certifiers are clear what each score for each indicator sub-criterion means. Generally:

- A score of 100 denotes the ideal fishery performance;
- A score of 80 defines the minimum requirement for unconditional certification; and
- A score of 60 defines the minimum requirements for conditional certification.

Scores are assigned based on an independent consensual judgment of how the fishery performs in relation to the scoring guides. Once the indicators have been scored, each indicator can be aggregated up through the hierarchy. This is calculated by multiplying the indicator score with its respective weight, then summing the scores for each of the relevant nodes above them in the hierarchy (MSC 2001d). Aggregated scores can be presented for operational criteria, MSC criteria and eventually, each MSC Principle. For the fishery to be successfully certified, it must obtain a normalised, weighted score of 80 for each of the three Principles, and at least 60 for each MSC criterion (see example below) (MSC 2001b). The nature of the SIS allows weaker scores of less than 80 against some MSC Criteria to be compensated for by scores of greater than 80 against other MSC Criteria. A score of less than 60 will fail certification (MSC 2003). An advantage of the approach (and philosophy of the MSC) is for the gradual improvement of fisheries over time. Wherever a score is less than 80 (but >60) for an Indicator sub-criterion, operational sub-criterion or the MSC Criterion, it indicates that the performance is significantly deficient and allows Corrective Actions to be set for certification. If the fishery adopts the corrective actions, thus bringing the score to the benchmark level, a conditional certification is awarded (see Table 27 below) (MSC 2001b).

The example in Table 27 below is a preliminary assessment for the South Georgian Patagonian Toothfish fishery in the Southern Ocean (Moody Marine Ltd 2002). It displays the aggregated set of criteria under the under MSC Principles and the scores allocated to each. This example demonstrates the process used in the certification to obtain a result for each criteria and Principle. Table 27 displays the total aggregation for each operational criteria. The fishery obtains a 'pass' with each principle over 80. However, several criteria have received scores less than 80 and will require corrective actions to receive conditional certifications.[168]

Table 27. The assessment scores for the Patagonian Toothfish fishery in South Georgia.

MSC Principle	Indicator	Score	Overall Score
Principle 1: Sustainability of exploited stock.	1A	85.8	90.1
	1B	83.5	PASS
Criteria 1 & 3.	1C	91.7	
	1D	95.0	
	1E	84.5	
	1F	100	
Principle 2: Maintenance of Ecosystem	2A	82.3	81.4
	2B	81.5	PASS
Criteria 1 & 2	2C	79	
	2D	82.5	
	2E	75.7	
	2F	88.3	
Principle 3: Effective Management System	3A	86.9	90.3
	3B	96.6	PASS
Criteria 1 -17	3C	93.3	
	3D	90	
	3E	83.2	
	3F	96.7	
	3G	85.2	

(Adapted from (Moody Marine Ltd 2002)). The fishery is awarded a conditional certification.

[168] It should be noted that this particular fishery currently engaged in objection procedures MSC (2003).

8.6.3 Status

The Marine Stewardship Council is rapidly expanding as a successful eco-labelling program. It has gained funding support from a variety of government, corporate and charity sources and it has established offices in London, Seattle, and Sydney (MSC 2003). Increasing numbers of fisheries have become certified or have been nominated for certification and are engaging in preliminary processes. The MSC has also attracted several large scale and lucrative fisheries to its certification program, including West Australian Rock Lobster, New Zealand Hoki and Alaskan Salmon. The MSC is set to expand into the Asia / Pacific region with the likelihood that pelagic tuna and/or prawn fisheries will be assessed. A recent funding arrangement between the MSC and UK supermarket chain Sainsbury's has resulted in a three year project to investigate the management of tuna fisheries with the goal to ensure a sustainable supply (MSC 2000). With increasing legislative and public pressure for the sector to be accountable against sustainability principles, the MSC is an option for managers to publicly display a sustainable fishery. However, competing requirements amongst emerging indicator systems from different jurisdictions, the complexities involved with assessment, possible duplication of effort and potential trade issues may be a factor in the cautious approach to certification.

8.7 Analysis against the Conceptual Framework

The results of the assessment framework are displayed in Table 28 and Figure 62(a-e). The MSC scores well against the Strategic Outcomes component (Figure 62a), obtaining an above average result against understanding the focus system (2) and a high score in its contribution towards to broader societal sustainability (3). The MSC Principles and Criteria specifically set indicators and performance scores that describe the target species, ecological and management aspects of the system. The SIS then customises each assessment to the fishery under focus and presents the results to the public and stakeholders. The MSC, as a civil society based organisation, fulfils a unique role in terms of the independent verification of sustainable fisheries. Despite not being included in a broader formal reporting process, the MSC assessments are reported publicly and are recognised across several jurisdictions as a market based mechanism for achieving sustainable fisheries. It therefore contributes to an understanding of fishery sustainability issues in the wider ocean management context.

Against the System Processes (Figure 62b), the MSC scores highly in all components. The core structure, sub-structure and inputs obtain maximum scores (3) while the outputs obtain above average results (2.5). The MSC indicator system is driven by the core structure that forms the overarching definition (The Principles and Criteria) and clearly forms the basis of the framework. Target, environmental and management dimensions are established and are further subdivided and adapted for each fishery assessed under the standard. Under each criterion, contextually based objectives, indicators, and performance measures are constructed for assessment.

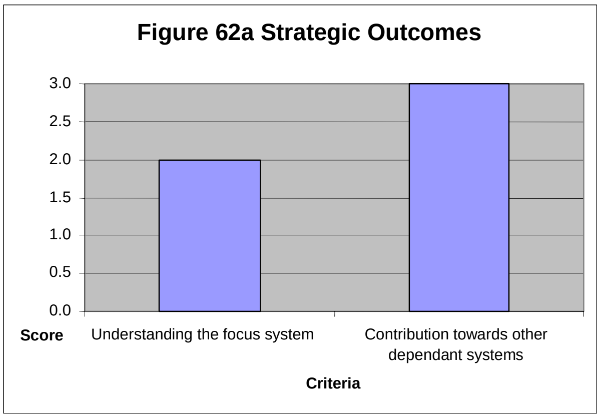
In terms of input parameters, the MSC methodology contains mechanisms for review and feedback of the draft scoring guidelines, reviews of the draft assessment, and ongoing monitoring of the performance of the fishery and conditional certifications. The MSC directly consults all stakeholders and has established a conflict resolution mechanism for assessment decisions. For outputs, the SIS maintains a regular and informative web-based reporting process (aided by a full-time communications officer in the head office), a methodology for aggregation, and high decision-making influence based on the results of the assessment. There is significant room for improvement in the visualisation of indicator data.

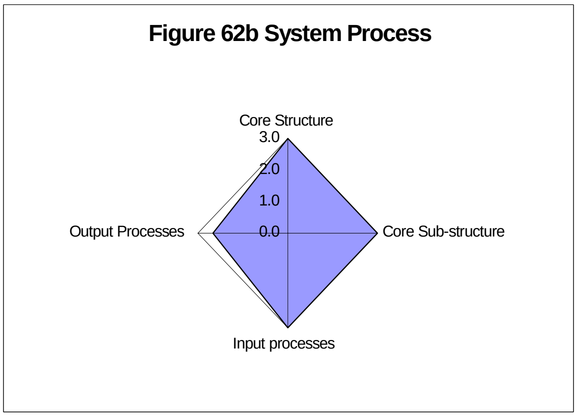
Against the System Features (Figure 62c), the SIS scores above average in all components indicating a strong commitment to best practice management approaches. Integrative capacity (2) displays an above average level of consideration in the SIS, with reporting and aggregation of target species, environmental and management system criteria. The MSC is expanding its effort to report on fisheries in developed and developing countries, and report on all forms of gear usage. In this aspect the MSC approach integrates across jurisdictions, the sector and gear types. However at this point in time, a low number of MSC assessments exist. These are expected to increase as increased numbers of fisheries are assessed under the program. In terms of adaptive management, a basic use of socio-economic indicators exists in the MSC approach, but could be significantly improved. Future review of the Principles and Criteria would assist this recommendation. Governance indicators are well developed and used in the system. The MSC and the certification body routinely monitor the SIS and its performance. A recent governance review by the MSC established a formal dispute resolution procedure and increased involvement by stakeholders to ensure transparency in decision-making. For project management, the MSC maintains adequate institutional capacity and has implemented a rigorous marketing approach. As a result the SIS is increasingly recognised as a useful and innovative market based approach.

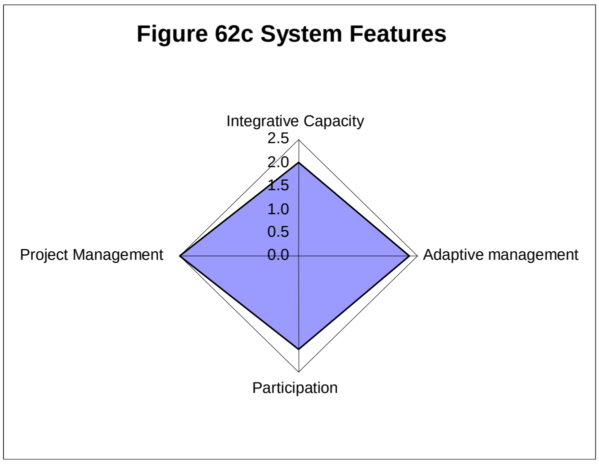
Table 28 Scoring for Case 10

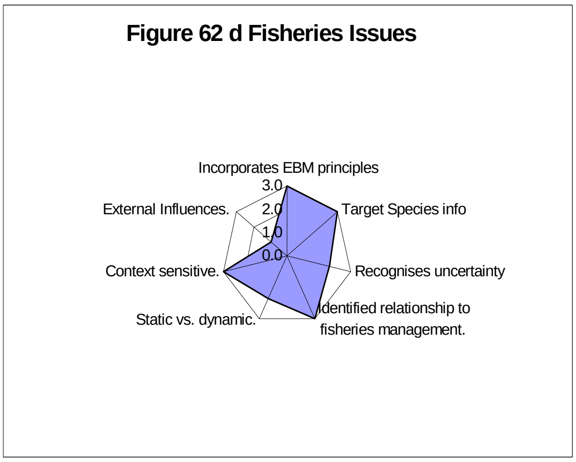
Case 10 The Marine Stewardship Council Certification Process				
Strategic Objective	**Sub Objective**	**Operational Objective**	**Score**	**Notes**
1. Strategic				
	Understanding the focus system	*System state and viability*	2	MSC approach fouses on understanding the fishery and its management. Fig 60
	Contribution towards other dependant systems	*System contribution to broader societal sustainability.*	3	The SIS promotes sustianable fisheries world wide, contributing to public understanding.
2. System Processes				
	Core Structure	*Interpretation and definition of sustainability.*	3	Strong defintion that establsihes framework.Figure 60
		Framework classification.	3	Hierarchical issues based approach and scoring method. Fig 61
		Dimensions of sustainability.	3	Structure follows hierarchical thematic approach based on definition. Fig 61
		Criteria and sub-criteria.	3	Explicit breakdown of issues through the MSC Principles and Criteria, and adaptation to fishery.
	Core Sub-structure	*Objectives*	3	Objectives are set for each fishery based on context specific considerations.
		Indicators: Scientific	3	Clear measurable indicators.
		Indicators: Functional	3	Indicators facitate certification and management system improvement.
		Performance values	3	Scoring guideposts represent performance values. Are aggregated for overal score. Table 27
	Input processes	*Policy context*		n/a
		Indicator feedback	3	Establsihed review process for MSC Principles and Criteria and setting of indicators.
		Stakeholder / user feedback	3	MSC governance process facilitates stakeholder input.
	Output Processes	*Visualisation & presentation.*	1	Minimal use of visualisation techniques. Written report based .
		Communication & reporting	3	Web based process. Regularly updated and informative.
		Aggregation and indices	3	SIS develops normalised scoring approach that aggregates to the highest level. Fig 61, Table 27
		Decision making influence	3	SIS desiged to influence the fishery management process. Fig 59
3. System Features				
	Integrative Capacity	*Interaction of sustainability dimensions.*	2	The SIS integrates target, associated and dependant species & management measures.
		Integration with other reporting systems and sectors.		n/a
	Adaptive management	*Social indicator development.*	2	Basic use of socio-economic indicators. Fig 60
		Institutional indicator develop.	3	Governance indicators well established. Fig 60
		System monitoring and feedback.	2	monitoring through the MSC and through the certification body.
	Participation	*Participation of stakeholders*	3	Stakeholder driven process.
		Participation of decision makers and relevant institutions.	1	MSC an independent body. Voluntary process.Requires uptake by government authorities.
	Project Management	*Institutional Capacity*	3	MSC and certification body have sufficient capacity. MSC developed training and monitoring processes.
		Marketing and R&D	2	MSC markets SIS. Emerging recognition of useful approach.
4. Fisheries Issues				
	Incorporates Ecosystem Mgt Principles	*SIS reflect broader ecosystem based management principles.*	3	EBM approaches present within the structure of the SIS. Fig 60
	Target Species info	*Indicators assess state of the target stock , used in management plans.*	3	Target species assessments present. Fig 60
	Recognises precaution	*Assessments explicitly recognise all forms of uncertainty.*	2	The SIS develops indicators recognising uncertainty and use the latest information.
	Identified relationship to fisheries management.	*Indicators feedback to mgt.*	3	MSC certification directly improves management of fishery. Focus for the SIS.
	Static vs. dynamic.	*Static and dynamic reporting within SIS.*	2	MSC indicators assess stock status, quantity and flows of resources. Staged process & ongoing.
	Context sensitive.	*Does the SIS take specific fisery context isues into account?*	3	SIS meaures at the the fishery level, harvesting process, limits at landing point.
	External Influences.	*Information on overcapacity, subsidies, trade, fleet structure, IUU fishing and external influences.*	1	Lack of external influences. SIS focus on direct fishery system. Chain of custody for trade issues.

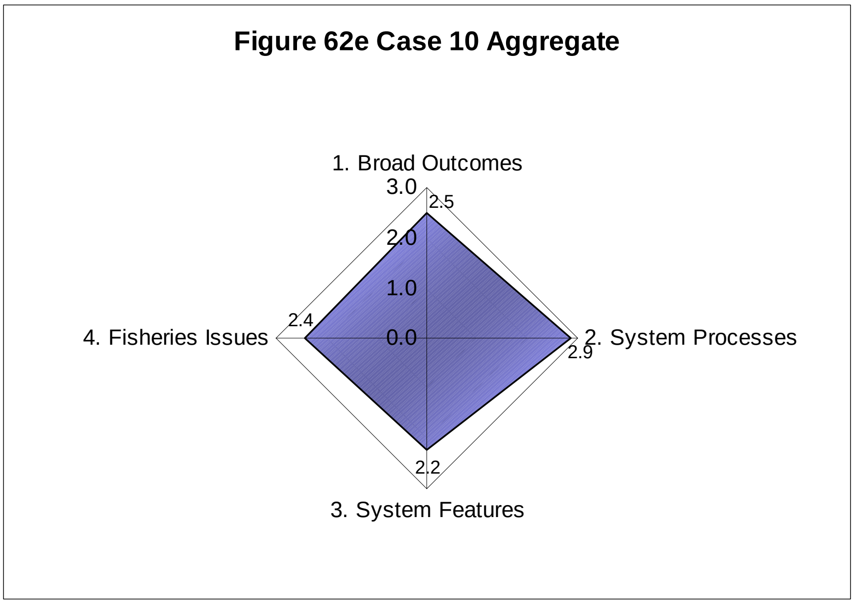
Figure 62(a-e) Orientation graphs for Case 10











For Fisheries Issues (Figure 62d) the case is focused upon ecosystem and target species indicators and maintaining direct relevance to fisheries management. It scores the maximum value in these components displaying recognition and commitment to ecosystem based management and a detailed target stock assessment process. The key strength of the SIS is its ability to independently assess fisheries and feed these results into the management process via certification. Conditional certification and ongoing review signify that the fishery is meeting these requirements in its management plan (hence the high score in management relationships). Incentives for fisheries involvement is generated through increased market leverage and the third party recognition of sustainability, and have resulted in significant interest from fisheries across several jurisdictions. Improvement in this component would come from increased recognition and assessment of external influences in fisheries, an area of which stakeholders have been increasingly concerned.

The Case Aggregate (Figure 62e) chart reveals a well-balanced and high scoring indicator system, with a focus towards System Processes (average of 2.9) and Fisheries Issues (average of 2.4). As recognition of this approach grows and an increasing number of fisheries are attracted to certification, the effectiveness and coverage of the MSC will increase. The direct benefits of eco-labelled fisheries are yet to be realised and ongoing participation and improvement of the scheme will assist in the growth of the MSC.

8.8 Conclusion

The involvement of non-State actors in the management of global fisheries has increased in recent years, with the MSC and its indicator system taking the lead in fishery assessments and improving the management of certified stocks. Primary factors in maintaining the MSC role as in independent assessor and certifier is the ongoing autonomy of the MSC process from corporate/industry pressures and the strict adherence to (and improvement of) the Principles and Criteria in the face of the perceived fisheries crisis.

Chapter 9: Synthesis

9.1 Introduction

This thesis set out to address the following aim:

To identify, investigate and strategically assess the use of indicator systems as tools for achieving and practically implementing sustainable development in a variety of marine capture fishery jurisdictions.

This can be divided into three specific objectives:

1. *Identify the generic structures, processes and concepts that underlie indicator systems and influence their effectiveness. What are indicator systems?*
2. *Investigate the application of indicator systems within a variety of fisheries jurisdictions and contexts. How are indicator systems applied in management?*
3. *Strategically assess the role of indicator systems across fisheries jurisdictions. Do SIS improve outcomes in terms of sustainability?*

To address these objectives, an assessment framework was developed to examine the structures and processes within indicator systems, identify and compare indicator systems in practice, and examine the outcomes in relation to sustainability. Each component of the framework has been described in Chapter 3. This thesis has employed a systems view of sustainability that is explored by Moldan (1997), Meadows (1998), Bell & Morse (1999), Bossel (1999) and Dovers (2001). A systems view is able to capture and investigate the complex relationships, influences and processes within indicator initiatives and facilitate analysis of these structures.

This chapter brings together the empirical evidence and scoring results from the case studies based on the assessment framework. Each case can be considered as a stand alone, *in situ* examination of an indicator system within a unique, complex, socio-economic, and political setting. Identifying the common elements of systems across different jurisdictions (by the ‘most different’ comparative method) provides opportunities to consider the common issues, challenges and outcomes of using indicator systems as tools in fisheries management. Comparison between different cases based on a common assessment framework can increase the understanding of complex socio-economic and political processes, and result in policy improvements.

This chapter uses a software tool to explore the ranking of different indicator approaches according to scoring from the conceptual framework. The visualisation software, called the Dashboard Model[169], calculates the performance of the different cases by assigning a performance rank to each criteria (a normalised score out of 1000) and aggregates the criteria into an overall index. Cases can be compared on the basis of their overall performance index, their sub-components or individual indicators.

9.2 Objective 1: Theoretical structures

The SIS model, assessment framework, and case studies are the analytical tools employed to address objective One. The objective focuses on the conceptual and generic structures that underlie all indicator system development, influence outcomes, and contribute towards sustainable management. An important point to note is that these structures apply to any indicator system and are not limited to fisheries. After identification, each generic structure is interpreted into the context of the case studies, displayed in the matrix below (Table 28).

The SIS model (Chapter 3 Figure 13) was developed from observations in the literature and from direct research, and has been successfully applied to all case studies. Use of this model therefore implies that it reflects a systems view, generic structure and basic processes of an indicator system. The model does not impose a fixed and rigid structure upon an indicator system. Adapting to meet new information and incorporating evolving policy demands is a feature of the SIS approach. Applying the SIS model and the linked assessment framework to the case studies results in a distillation of the key structures and processes (Table 29). It primarily uses results from the assessment framework focusing on the System Processes and System Features criteria and empirical information generated directly from the case studies. This classification leads to increased understanding of the use and structure of indicator systems across a range of jurisdictions and cases and contributes to improved SIS design, implementation and monitoring.

[169] The Dashboard Model was developed by Jochen Jesinghaus of the European Commission Joint Research Centre (JRC) and can be downloaded from http://esl.jrc.it/dc/index.htm

Table 29 Results Matrix for Objective 1

	Case 1: SoE	Case 2: EPBC	Case 3: SCFA	Case 4: NEIS	Case 5: NRTEE	Case 6: OBFM / MEQ	Case 7: TLM	Case 8: EPI	Case 9: CCAMLR	Case 10: MSC
Framework	Thematic & Condition-State-Response framework	Thematic subdivision: Fisheries based.	Hierarchical subdivision: ESD based.	Issues-based & Pressure- State-Response framework.	Hierarchical subdivision: Capital Model.	Ecological thematic subdivision & process based framework.	Biological & precautionary based framework.	Thematic based and Pressure-State-Response framework.	No framework - developing biological thematic.	Thematic subdivision: fisheries based.
Dimensions	Target Species, Environmental	Target species, Environmental, governance.	Target species, environmental, social, economic and governance.	Environmental, target species.	Social, human, natural and produced capital.	Target, Environmental, Socio-economic.	Target Species.	Target, Environment, Governance.	Target, Ecological.	Target, Environmental, Governance.
Indicator Status	Well researched, but lack of information for use. Employ proxies. 61 indicators under 8 criteria.	Flexible, subjective reporting. 28 criteria under 3 Principles. Non-quantitative measures.	8 generic component trees (criteria). Subdivided into specific indicators. >40.	Limited. PSR divided into criteria & indicators. 8 indicators identified.	3 indicators, highly aggregated. 6 potential in Fisheries Cluster.	MEQ >25 indicators under 3 criteria, subdivided. OBFM >20 indicators under management objectives.	Peer reviewed, scientific indicators >20 under biological criteria.	5 criteria in Marine Environment, 17 fisheries specific indicators.	No formal indicators. >20 CEMP parameters monitored. 5 aggregate measures proposed.	>50 fishery specific indicators under 23 criteria, 3 Principles. Adapted to each fishery.
Objectives	Objectives set for each indicator	Specific objectives set for each principle.	Clear, specific objectives set for each indicator.	Lack of operational objectives.	Objectives exist at strategic scale only. Research on indicator specific ongoing.	Clear objectives set for MEQ & OBFM indicators.	Fishery based indicators linked to OBFM. Indicator level objectives specified.	Objectives detailed for each indicator.	CEMP level established. Under review. Indicator level developmental.	Strategic and fishery specific objectives exist.
Performance measures	Minimal performance measures.	No performance measures. Subjective reporting.	Performance measures set for each indicator.	No performance measures.	No performance measures.	Developmental performance measures. Thresholds for MEQ. Explicit in OBFM.	Detailed performance measures for each indicator. Allocate the TL colour.	Performance measures implied in each indicator. Ongoing development.	Ongoing development of performance measures. Commitment to reference points.	Performance measures set for each indicator.
Policy Context	Legislated Process under EPBC Act	Legislated process under EPBC Act. All assessments by Nov 2003.	National industry / Agency driven project (SCFA). Formal policy in West Australian fisheries.	Environment Canada initiative. Early SoE based approach.	NRTEE initiative, Federal support and financial backing to report on capital assets.	Based on Oceans Act, Fisheries Policy review, Auditor general report and emerging best practice.	Developed through RAP and FMSWG to incorporate precaution in assessments.	Defined policy context. Coordination and reporting on environmental policy issues.	Based on CCAMLR convention and Article 2.	Independent initiative. Market based approach.
Information input	Ongoing collection of indicator data.	All Commonwealth and export fisheries being assessed under guidelines.	Recent case studies completed. Development of "How To" guide for implementation.	No monitoring or feedback. SIS superceded.	SIS at Phase 3, testing of indicators, case studies & reporting format.	MEQ ongoing development with recent national workshop. OBFM generating pilot case studies	Formal review and research process by FMSWG.	Consultation and indicator feedback established. Development of Type 1 indicators.	Formal data input via Scientific Commission and WG-EMM.	Reviewed by MSC council and adapted by certification bodies.
Reporting Output	Published nationally every five years. Wide range.	Final reports available online and to stakeholders.	Case studies and guide available online. No further progression.	Web based bulletins. Halted as other initiatives superceded.	Regular reports available on progress, methods and indicators.	No formal reporting. Ongoing development. Linked to fisheries management.	Reporting through DFO Maritimes fishery plans and stock assessments.	Web based reporting. Regular updates.	Annual reports through CCAMLR.	Reports on candidate fisheries against MSC principles and criteria. Web based.
Visualisation Output	Minimal use of visualisation techniques.	No visualisation.	Use of component trees. Still developmental.	Basic visualisation, web based flow chart.	No visualisation.	Basic visualisation techniques. Component trees for MEQ.	Advanced visualisation technique, Traffic Lights based on reference points.	Basic visualisation techniques. Development of web & GIS based.	No visualisation techniques.	Minimum use of visualisation.
Aggregation Output	No aggregation.	No aggregation.	No aggregation.	No aggregation.	Aggregation discussed in detail and several approaches suggested. Fishery indicators are aggregate scores.	MEQ indices proposed. Ongoing development.	Aggregation methodology established.	No aggregation.	Use of Indices. Issue explored.	Aggregation methodology established.

As shown in Table 29, the structures and processes that underlie indicator systems (on the basis of the SIS model and empirical case evidence) can be identified across the range of cases. These elements include:

- Frameworks
- Dimensions
- Indicator status
- Objectives
- Performance measures
- Policy Context
- Information input
- Reporting Output
- Visualisation Output
- Aggregation Output

9.2.1 Frameworks

The ordering of indicators into a coherent framework can lead to improved understanding over which indicators to use to achieve outcomes; to understand system dynamics; and to promote clarity and objectivity. The cases illustrate a range of frameworks that frame the organisational structure of each SIS. Frameworks determine the order of the information for the assessment, what dimensions are considered, and its overall scope and structure. The selected framework is often a derivative of the definition, the policy focus and the sectoral needs. The framework therefore can be orientated towards a specific policy context. It is important to note that it is not critical which framework is chosen, as long as it fulfils the policy purpose.

The cases identify four predominant frameworks at use in fisheries systems: pressure-state-response (P-S-R) frameworks, thematic subdivisions, hierarchical subdivisions and process driven frameworks. The PSR model has been used extensively in a variety of economic and resource management institutions and has been imported into a several fisheries initiatives. The PSR framework has been used in Australia, New Zealand and Canada (Cases 1,4 and 8) and provides a concise basis for selecting and ordering fisheries indicators. Thematic subdivisions order indicators along a particular theme and are a common approach to disaggregate issues. Themes include a national set of environmental issues (Cases 1, 4, 8), specific fisheries management themes (Cases 2, 6 and 10) or ecological themes (Cases 6, 7, and 9). Hierarchically subdivided frameworks are similar to thematic frameworks and order information along the lines of issues, but specifically employ a process of 'unpacking' using component trees to identify issues (Cases 3 and 5).

Often, as shown by the case material, frameworks have been combined as an additional step in ordering the information and breaking down the issues. For example in the Australian

State of the Environment and New Zealand EPI Program (Cases 1 and 8), a thematic framework is combined with a Pressure-State-Response framework. The thematic approach identifies the range of core policy issues while the P-S-R framework divides each issue into a series of pressure, state or response indicators.

9.2.2 Dimensions

'Dimensions' refer to the broad and conceptual categories that contribute to the notion of sustainable development, and include, but are not limited to environmental (often ecological and/ or target species), social, cultural, economic, political, governance, institutional, capital, human, and technological spheres. Achieving sustainability depends on satisfying to a certain degree all of the dimensions (i.e. the environmental, social and economic aspects of an issue). Indicator systems as policy constructs have however, limits on the financial input and expertise that drive the assessment. One indicator system, no matter how technically proficient, cannot be expected to facilitate and assess all the required dimensions of sustainability. The dimensions that are chosen for the indicator system will affect assessment; a key challenge will be to integrate information and assessments from different dimensions.

Selection of the dimensions sets the scope of the SIS and is often influenced by the definition and scope of sustainability. There is no right or wrong answer to defining the dimensions, as each consists of a different approach to conceptualising sustainable development. What is important is that the dimensions are oriented towards the purpose of the SIS, usually on the basis of a policy context. Traditionally most sustainability indicator systems have been oriented towards the environmental dimension. Fisheries maintain however a strong socio-economic basis and emerging practice requires these dimensions to be considered in any assessment or report.

The cases have identified dimensions that focus primarily on the environmental sphere. All cases address the environmental dimension in terms of target species and to a lesser extent ecological considerations. It is clear from the case studies that ecological dimensions are increasing in stature in fisheries indicators, and that research is focusing on this aspect of fisheries management. Cases from Australia (2 and 3), Canada (Case 6), New Zealand (Case 8), CCAMLR (Case 9) and the MSC (Case 10) reflect an increased focus on ecosystem aspects of fisheries management. CCAMLR for example established an ecosystem assessment and related decision rules for management. Socio-economic and governance dimensions are also emerging in indicator systems but still require further development in terms of direct measurable indicators and supporting data. Cases from Australia (Case 2 and 3), Canada (Case 5 and 6), New Zealand (Case 8) and the MSC (Case 10) have all established socio-economic or governance dimensions as a part of their respective indicator systems.

9.2.3 Indicator Status

The selection of indicators is linked to the development of the framework and selection of the dimensions (as shown in the SIS model). The dimension under consideration is divided into a number of specific criteria that facilitates the setting of measures (the indicators). All the cases demonstrate this form of sub-division, guided by their frameworks detailed in 9.2.1. For example, the NESDRF indicator system (Case 3) subdivides the dimensions into specific issues: *Effects on Humans* and *Effects on the Environment*. A number of component trees (criteria) have been generated and represent a breakdown of a dimension to a practical level by adapting a tree to a particular fishery. Once the issue has been broken down, objectives, indicators and reference points can be established. The Canadian NRTEE (Case 5) takes a slightly different approach using hierarchical subdivision process to divide the dimensions of *capital* into its various forms (e.g. social, human, produced and natural). Natural capital, for example, is split into the forms of renewable and non-renewable resources, of which fisheries form a subset. In this particular case, the indicators that have been chosen represent highly aggregated measures that summarise the quantity and quality of stocks and ecosystem outcomes of services. The MSC initiative (Case 10) uses a thematic subdivision to identify indicators based on a set of strategic principles and criteria. The principles and criteria apply to every fishery assessed under the eco-labelling program. All cases show how the process of indicator selection and distillation is common to all systems and adapted by each particular framework (Table 29).

A source of variance across the case studies is the level of scientific development of the indicators. Based on the information that is required for measurement and implementation, the cases can be classified into developmental or advanced indicator series. Developmental indicators refer to series that are in a state of development and review, and generally require more information to be considered effective. Cases that have been identified as developmental include SoE (Case 1), NESDRF (Case 3), NEIS (Case 4), NRTEE (Case 5), MEQ / OBFM (Case 6), and CCAMLR (Case 9). These cases are in the process of further developing the information basis for their indicators. Cases that are in an advanced (or developed) state have a relatively comprehensive indicator program that is applied to fisheries cases with quantitative or qualitative results. Cases include the EPBC (Case 2), TLM (Case 7), EPI (Case 8) and the MSC (Case 10).

9.2.4 Objectives

The objectives represent the desired goal for the indicator system and ask the question 'what do we want to achieve?' The objectives are a core component within the SIS and often exist at multiple scales. At the strategic level they define the purpose of the indicator system and are generated from policy statements, strategic plans or legislation. Conceptual objectives, while important for setting strategic focus, can be interpreted in different ways by stakeholders. This can lead to multiple views on what the SIS is trying to achieve and what it is trying to measure.

To facilitate transparency and clarity in decision-making, the objectives must be filtered down into operational statements that link back to the conceptual objectives. This is a challenge for SIS implementation as the majority of objectives exist at the conceptual level but do not exist at the operational level. As shown in the SIS model an objective should be set within the core sub-structure to define and set the aim for each indicator. Operational objectives ask the question 'what is the indicator trying to achieve?' and directly influence the form of the measurement. Setting the objectives for indicators has focused increased attention on management processes, as stakeholders need to identify the conceptual objective and then agree on a suitable indicator based objective. It has essentially forced the attention onto defining specific goals for management systems beyond the conceptual level. Therefore, one of the advantages of using indicator systems in management is the distillation of specific objectives that can be agreed upon, measured, and achieved. This process of setting objectives has been identified across the cases and reveals that this process is critical in generating effective outcomes.

The cases (Table 29) reveal a diversity of approaches and performance in terms of setting indicator specific objectives. Two classifications have emerged. The SoE (Case 1), NESDRF (Case 3), MEQ/OBFM (Case 6), TLM (Case 7), EPI (Case 8), and the MSC (Case 10) have developed indicator specific operational objectives. Of these cases the MEQ/OBFM, EPI and MSC are the most advanced with detailed and specific objectives for each indicator that defines its purpose and establishes the form of measurement. The EPBC (Case 2), NEIS (Case 4), NRTEE (Case 5), and CCAMLR (Case 9) have developed overall conceptual objectives and are in the process of identifying increasingly specific operational indicator objectives. The EPBC SIS has set objectives at the criteria level and applied them directly to its qualitative reporting process.

9.2.5 Performance Measures

An important feature of SIS is that they endeavour to improve management by assessing performance in relation to objectives. Once objectives and indicators have been established, a measure of performance is necessary to gauge progress towards or away from the goal. A performance measure is a function that converts the value of an indicator to a measure of management performance with respect to the operational objective (Fletcher et al 2002).

Performance measures can take a variety of forms including reference points, temporal changes, trends, direct outcomes and subjective reviews. Fisheries management has increasingly used the concept of reference points for determining performance. Reference points refer specifically to the use of quantitative limit and/or target thresholds to determine the performance on an indicator (Bell & Morse 1999; Bossel 1999). A limit reference point is associated with an unacceptable outcome in a precautionary context (such as a biomass limit on a stock) (Halliday et al 2001). A target reference point defines a condition that is acceptable or desirable to achieve (such as the traditional $F_{0.1}$ that is defined as a stock mortality rate in harvesting). The setting of reference points then flows into decision rules that act upon management arrangements.

Performance measures and reference points have increasingly been extended to cover a range of indicators other than fisheries stocks. It is important to note that not all indicators require performance measures. For example, certain measures of environmental conditions or driving socio-economic forces are not able to be subjected to management improvement or direct intervention but still provide important reference information.

The selection of performance measures provides a conceptual and technical challenge to emerging indicator systems. It is a complex task to determine what constitutes success or failure with an indicator measurement and what management action that will trigger. This is compounded when a large number of indicators exist with different concepts on what constitutes performance success. The setting of performance measures is a significant feature of the SIS and reflects its influence in decision-making. The pioneering work in the fisheries sector provides valuable lessons on how reference points and performance measures can be implemented. The evolving application of Management Strategy Evaluation that uses reference points and predictive modelling as the basis of setting probabilities for management success would also provide interesting insights into the development of performance measures (Smith 1999; Fletcher et al 2002).

All the cases have expressed the importance of using indicators as a means of management improvement and a tool to progress towards sustainability. Investigation of the case studies reveals a range of performance measure development. This varies from no performance measures in the SIS to quantitative measures linked to specific decision rules. The systems that have performance measures in initial stages include SoE (Case 1), NEIS (Case 2), NRTEE (Case 5), and CCAMLR (Case 10). These indicator systems have identified measures as important but are yet to directly apply the concept in practice. CCAMLR has developed target and limit reference points for target stocks but is yet to expand the concept into its ecosystem management program. Cases that have developed performance measures as a part of their SIS include the EPBC (Case 2), NESDRF (Case 3), MEQ/OBFM (Case 6), TLM (Case 7), EPI (Case 8), and the MSC (Case 9). The EPBC approach has not developed specific performance measures but instead employs a subjective approach where the results are subjected to ministerial review, a form of qualitative performance assessment. The TLM is also of particular note, having applied reference points to a variety of indicators with a linked visualisation methodology. The ‘traffic light’ signals directly relate to the position of the indicator in relation to its reference point, and feed back to form decision rules. The use of performance measures in indicator systems is a vital one for determining effectiveness. As indicator systems develop increased information on measuring performance, a variety of methods and reference points are expected to advance.

9.2.6 Policy Content

This component is expanded under Objective 2 below. It has been included in both evaluations as it represents a significant theoretical process and practical application for fisheries management.

9.2.7 Information Input

Information input refers to the ability of the indicator system to take into account new information and inputs (see SIS model Chapter 3 Figure 13). This can include new research on the core sub-structure (new indicators, distillation of objectives, and performance measures), new policy priorities, stakeholder feedback, and the results of monitoring. This input of information is influential upon the context and content of the SIS and represents an ongoing commitment to improve the quality of information.

Indicator systems are not static. Adaptive management is a key of the indicator system, new information is constantly being generated, and how this information is included into the SIS will influence its effectiveness. The cases display a variety of commitments to information input, with a mix of formal and informal approaches. The cases focus on the information input that directly relates to indicator specific developments.

In terms of this generic process, all case studies except NEIS (Case 4) maintain a process for including information into their structures (see Table 28). The NEIS system, despite still being publicly available, has been superseded by other initiatives such as the NRTEE. The process of information input varies amongst the cases, with two patterns identified. Several cases are in a process of testing draft indicators (Cases 1, 5, 6, 9) or applying established indicators to fisheries operations (Cases 2, 3, 7, 8 and 10).

9.2.8 Reporting Output

Outputs represent how the information generated from the SIS is used in decision-making (see SIS model Chapter 3 Figure 13). Effective reporting of the indicator results influences the clarity, acceptability and influence of the indicators. Conversely, a poor reporting system will lead to poor decision-making outcomes.

How the information is used from a SIS is vital to its success. This process refers to the ability to produce a report that contains a description of the methods, results, interpretations and conclusions. A sufficient reporting mechanism is required to communicate indicator system results to all stakeholders and the public. It informs the progress of the assessment, the results of the indicators, and any changes from policy or feedback. Essentially the report is the ‘public face’ of the SIS and can affect the acceptability of the system in practice.

The case studies reveal how reporting outputs vary according to time, jurisdiction and policy context. Reports are generated from all the cases and vary from progress reports of developmental systems and indicators, the update of indicator results, and the outcomes of SIS based fisheries assessments. In terms of progress reports, the NESDRF (Case 3), NRTEE (Case 5), MEQ/OBFM (Case 6) and CCAMLR (Case 9) systems are producing updates on status and progress. The NESDRF has recently produced a ‘how to’ guide on SIS implementation (Fletcher et al 2002) available to all stakeholders online. The NRTEE initiative has developed regular online reports that keeps stakeholders and the public informed of progress (NRTEE 2002a; NRTEE 2002b). Reporting on the update of indicators and their results is an important process that encourages participation and informed decision making. Reporting on the status of indicators after new information is obtained from monitoring is a critical process that improves the quality of the measures. This level of reporting is found in SoE (Case 1), TLM (Case 7) and the EPI (Case 8). Assessment based indicator systems represent the most advanced form of reporting as they feed directly into management processes. The EPBC (Case 2) and MSC (Case 10) both assess fishery systems, report on outcomes and influence management process.

9.2.9 Visualisation of Output

A visual design strategy should be used to transmit summarised indicator information to stakeholders and decision-makers. An effective visualisation strategy enables the clear and effective assimilation of indicator information and promotes wide discussion and debate of the indicators. Visualisation is important process for summarising lengthy reports and supplements the aggregation process. Whereas aggregation condenses information into indices (often with a loss of specific information), visualisation promotes the rapid interpretation of indicators in a simple and effective format. It facilitates the communication of information, an essential component of managing for sustainability.

Investigation of this process across the cases reveals that visualisation methods are yet to be developed for several SIS. The EPBC (Case 2), NRTEE (Case 5), and CCAMLR (Case 9) have not developed any form of visualisation methods. The EPBC uses a qualitative reporting process, designed for maximum flexibility. This has resulted in lengthy reports that are the basis of a ministerial assessment process. A lack of visualisation can limit stakeholder participation in the review process. Several indicator systems are at the stage of developing basic visualisation processes. The SoE (Case 1), NESDRF (Case 3), NEIS (Case 4), MEQ/OBFM (Case 6), EPI (Case 8) and MSC (Case 10) have initiated basic visualisation techniques that include use of component trees, web based approaches, flow charts, and geographical information systems. These approaches require further development before the visualisation strategies can be considered effective.

The most advanced use of visualisation techniques is provided by the TLM (Case 7). It generates 'traffic light' signals based on the position of the indictor against a predetermined reference point, and clearly displays the status of the indicator in a simplified communicative format. The use of traffic lights has been adopted by the DFO Maritime management authority as the basis of stock assessment and has been applied to several finfish and shellfish stocks in the Atlantic region (DFO 2001; Halliday 2001). In addition the TLM has been investigated as a potential MEQ visualisation tool (Arbour et al 2001).

9.2.10 Aggregation of Output

A key challenge for SIS is to address the issue of aggregation in order to present a series of a few highly relevant indicators that can be used for key policy decisions. While large lists of indicators are necessary for expert and technical assessments, aggregate indicators are necessary for highlighting general problems and priorities to policy makers, the media, and the public. Aggregate indicators, often termed indices, are measures that have combined a series of indicators via a mathematical function and converted these to a common metric.

Just how far aggregation is to proceed, whether to one all encompassing index or a series of indices of related indicators, is the basis of ongoing debate within the indicator community.

Aggregation is a useful concept within indicator systems that enables measurements at a lower scale (for example, local level) to be incorporated in reporting at a higher scale (for example, national scale). As the scale increases, indicator information reaches a broader range of interests but becomes increasingly generalised and loses detail. Over-aggregated indicators can conceal significant local variation that is important, perhaps even critical for the system at that scale and can give a false signal to decision-makers.

The demand for aggregated indicators reflects calls for simplicity and clarity. Since public education and political action are seen as a focus for SIS, a means of presenting simple and effective indicators without compromising the underlying complexity is an important step (Meadows 1998). Aggregation is an important output of SIS but needs to be placed within the context of the objectives. A methodology that finds a balance between technical requirements and policy utility is a key feature of an indicator system.

Observation of the case studies reveals that aggregation outputs are in an early stage of development. The SoE (Case 1), EPBC (Case 2), NESDRF (Case 3), NEIS (Case 4) and EPI (Case 8) have no aggregation methodologies established within their structure. It is highly unlikely that these systems will develop aggregation methodologies in the near future. However the EPI system is currently investigating the method of using headline indicators that identifies single important indicators that represent the overall system. The NRTEE (Case 5), MEQ/OBFM (Case 6), TLM (Case 7), CCAMLR (Case 8) and the MSC (Case 10) have established comprehensive discussion or implementation of aggregation methods and outputs. There is a strong trend of Canadian indicator systems discussing the notion of aggregation. The NRTEE is investigating several methods based on the capital approach and debating the issues around standardising through monetary values. The MEQ process is investigating the introduction of environmental quality indices and the TLM has developed an aggregation process for biological indicators based on its visualisation output. The MSC initiative has developed an aggregation methodology based on its scoring criteria for each indicator that is directly linked to the awarding of the eco-label after the required score is obtained.

9.3 Objective 2: Application of SIS to fisheries management.

The methodological tools used to address Objective 2 are the case studies and the assessment framework. Whereas Objective 1 identified theoretical structures and processes within indicator systems, Objective 2 takes a practical approach and assesses the use of indicator systems within a variety of fisheries jurisdictions.

The case studies are the primary means of identifying and assessing the use of indicator systems within fisheries jurisdictions. Each case presents a unique *in situ* account of the development and use of indicator systems within national, regional and non-government jurisdictions. Each case study follows a set template to structure the analysis detailing the background, structure, indicators, and status and empirically examines the way indicator systems are adapted to each specific context.

The assessment framework further clarifies the use of indicator systems in practice and subjects each case study to scoring criteria. Cases are scored against the strategic outcomes, system processes, system features, and fisheries issues (further subdivided into a set of operational criteria). For each case study a set of orientation graphs have been produced that quantify the performance of each indicator (see chapters 4-8). In terms of addressing this objective, this analysis draws on the strategic, system features and fisheries issues criteria of the assessment framework. The components identify the issues and outcomes that relate to the practice of indicator systems within fisheries jurisdictions. The components form the basis of the matrix below (Table 30). They include:

- Decision making scope
- Policy Context
- Jurisdiction
- Relationship to fisheries management
- Reporting Scale
- Ecosystem management indicators
- Target species indicators
- Socio-economic indicators
- Precaution and uncertainty
- Participation
- Status

Table 30 Results Matrix for Objective 2

Table 30. Results Matrix for Objective 2

	Case 1: SoE	Case 2: EPBC	Case 3: NESDRF	Case 4: NEIS	Case 5: NRTEE	Case 6: OBFM / MEQ	Case 7: TLM	Case 8: EPI	Case 9: CCAMLR	Case 10: MSC
Decision making scope.	Broad reporting system. Fulfils public education role.	Fisheries specific assessment process.	Fisheries specific system for ESD reporting. Potential assessment / coordinating process.	Broad reporting, education and awareness tool.	Broad reporting. Intent to provide policy advice parallel to economic indicators, GDP.	Fisheries & Ecosystem reporting.	Fishery specific, stock assessment based.	Broad national environmental reporting and fishery specific.	Ecosystem based. Development of decision rules.	Market based and fishery specific. Independent audit rewards use of eco-label.
Policy Context	Legislated Process under EPBC Act	Legislated process under EPBC Act. All assessments by Nov 2003.	National industry / Agency driven project (SCFA). Formal policy in West Australian fisheries.	Environment Canada initiative. Early SoE based approach.	NRTEE initiative, Federal support and financial backing to report on capital assets.	Based on Oceans Act, Fisheries Policy review, Auditor general report and emerging best practice.	Developed through RAP and FMSWG to incorporate precaution in assessments.	Defined policy context. Coordination and reporting on environmental policy issues.	Based on CCAMLR convention and Article 2.	Independent initiative. Market based approach.
Jurisdiction	Federal Government (Environment Australia)	Federal. Govt. Environment Australia.	Fisheries Agency based. Coordinated through the SCFA.	Federal Government. Environment Canada.	National Round Table on Environment and Economy. Federal intergovernmental.	Federal. Department of Fisheries and Oceans (DFO).	Agency based. DFO Maritimes.	National Government. Department of Environment.	International treaty - CCAMLR.	Non-government, independent.
Relationship to Fisheries Management	No relationaship to management	External assessment of mgt plans by EA. Meet criteria for approval.	Voluntary reporting approach against ESD. Satisfy policy requirements	No direct relationship.	No direct relationship. National reporting on capital stocks.	OBFM part of fishery mgt planning. MEQ to be included in plans.	TLM a part of stock assessment process.	Indirect link to fisheries management. Reporting process for informing policy and public.	Ecosystem assessments feed into decision rules and alter harvesting.	Candidate fisheries must accept management conditions for certification.
Reporting Scale	National context. Aggrgate fisheries.	Fishery and gear based.	Fishery and gear based	Focus on economically significant fisheries.	National context. Fisheries of commercial & social importance.	Fishery and gear based. Links to current mgt plans. Will link to regional.	Stock and fishery based. Feed directly into management and assessment	Stock based. Reports on all fished stocks in NZ waters.	Stock based. Krill fishery.	Focus on candidate fisheries, gear and ecosystem.
Ecosystem management indicators	Minimal. Proxy indicators. More info required.	Yes. Guidelines address EBM concerns.	Yes. Component trees report on ecosystem and non-target species.	No. Target only.	Minimal. Measures VTE and habitat.	Yes. MEQ ecosystem assessment. OBFM non-target and bycatch.	Minimal. Some ecosystem paremeters. Evolving measures.	Yes. Non-target and habitat measures. More info required (Type 2 indictors).	Yes. Focus on krill centric ecosystem, associated and dependant species.	Yes. EBM core principle for assessment and certification.
Target Species indicators	Yes. Commonwelath stocks. More info required.	Yes. Guidelines address target stocks.	Yes. Component trees report on target species.	Yes. Target based.	Aggregate of target species for capital stock indicators.	Yes. Management plans based on target species.	Target focused.	Yes. Multiple target indicators.	Emerging. Krill centric. Ecosystem based decision rules to affect target	Yes. Core Principle of assessment and certification.
Socio-economic indicators.	Minimal indicators.	Minimal. Some management & governance.	Yes. Socio-economic criteria advanced.	Minimal use of indicators.	Minimal direct fishery indicators.	Yes. OBFM contains socio-economic indicators.	No socio-economic indicators.	Minimal. Some management and governance indicators.	No socio-economic indicators.	Yes. Management and socio-economic criteria present.
Precaution and uncertainty	Basic recognition. Not explicit or assessed.	Precautionary approaches are included in assessment.	Formal risk assessment to determine assesment issues.	Minimal precautionary measures.	Yes. Comprehensive testing of indicators and information uncertainty.	Yes. Uncertainty of paremeters recognised. Reference points in development.	Yes. Uncertainty explicity recognised. Intent of TLM is focus on precaution.	Type 1 & 2 indicators recognise information uncertainy & implement phased process.	Yes. Quantitative assessment of uncertainty and precautionary measures.	Yes. Extensive peer review of information and indicators in light of uncertianty.
Participation	Minimal. Top down reporting.	Top down process. Compulsory assessment.	High participation of stakeholders.	Minimal. Top down.	High participation of decision makers & stakeholders.	Agency participation. Ongoing consultation to stakeholders.	Effective participation of decision makers and industry. Improved	High participation of agencies and stakeholders.Coordination mechanism.	International participation through Scientific Commttee.	High participation of stakeholders. Formal conflict resolution process.
Status	Reports every 5 years. Latest 2001. Ongoing info development.	All Commonwelath & export fisheries assessed by Nov 2003. Ongoing review.	Case studies. Developed 'How to" guide. Application by agencies.	Discontinued.	Final stage of development and testing of indicators (Stage 3).	MEQ and OBFM in pilot case testing. Further devleopment of MEQ indicators.	TLM being applied to several DFO Maritimes fisheries. Improved decisin making.	Type 1 indicators published online. Further development of online reporting and Type 2.	Review of CEMP in 2003 and decision tools in 2005.	Application to several fisheries worldwide. Onoing development, Tuna fisheries.

9.3.1 Decision making scope

This refers to the influence of the SIS in relation to decision-making. The decision making scope influences the design of the SIS and determines how the results of indicators are used in the management process. Two categories have emerged in the decision making scope across the cases: broad national approaches and fisheries specific assessments.

National approaches are descriptive, cover a wide geographical range, are not fishery specific, and generally do not directly relate to fisheries management. They fulfil the purpose of public education, policy direction, and the raising of awareness on broader fisheries issues. This approach places fisheries within the context of natural resource management in other sectors with a 'state of the environment' output. Broad reports are generally not context sensitive, and focus on an extensive coverage of issues across a national jurisdiction. These systems can be compromised by a lack of specific fisheries information (such as stock status) and the availability of information between jurisdictions and issues. Several cases were identified that subscribe to the broad reporting process including SoE (Case 1), NEIS (Case 4), and NRTEE (Case 5). The New Zealand EPI (Case 8) represents a broad national environmental reporting process but in addition maintains a detailed fishery specific component that directly relates to management process.

Fisheries specific assessments are the next classification of the decision making scope. These assessments refer directly to stock assessment issues, effects on the environment and the management process. They are focused on the dynamics of the fishery system and the sector. These approaches do not take account of broader environmental issues or sectors outside fisheries and fulfil a direct role in the management of the resource. Fisheries specific assessments can fulfil an educative role, but are highly technical and require expert knowledge of issues within the sector. Several cases fit into this classification, the EPBC (Case 2), NESDRF (Case 3), OBFM / MEQ (Case 6), TLM (Case 7), CCAMLR (Case 8) and the MSC (Case 9). Observation of these cases reveals that they have been designed around the basis of increasing the scope of fisheries management to include broader parameters other than the traditional stock assessment focus. This includes associated and dependent species, ecosystem, and socio-economic variables. Several systems have resulted from initiatives from *within* the fisheries sector (NESDRF, OBFM, TLM and CCAMLR) while other initiatives have originated from an *external* source (EPBC, MEQ, and MSC). The ability of external environmental organisations to affect traditional fisheries management is a key practical outcome of indictor systems.

9.3.2 Policy Context

The policy context is a determining factor in setting the scope for the SIS. It determines the relationship between the indicator system and the relevant institutions policy and /or legislative framework. The responsibility for establishing and maintaining the SIS and how the outputs of the indicator system are used is often detailed in the policy context.

Several indicator systems have a legislative basis. The SoE (Case 1) and EPBC (Case 2) have their basis within Australian Commonwealth environmental legislation and are administered by the Commonwealth environment agency. The OBFM/MEQ initiative (Case 6) has a legislative basis within the *Canadian Oceans Act*. The CCAMLR initiative (Case 9) has been developed within the context of an international treaty, the Convention on the Conservation of Antarctic Marine Living Resources, 1980.

Other indicator initiatives are not based within policy or sector driven initiatives (e.g. industry initiatives). The NESDRF (Case 3) was initiated by the former Standing Committee on Fisheries and Aquaculture, an organisation consisting of the heads of state and Commonwealth departments. The NEIS (Case 4) was initiated by the Canadian federal environment department. The NRTEE (Case 5) has its basis in the National Round Table on Environment and Economy, a Canadian intergovernmental ‘think tank’ that promotes initiatives on sustainability. The TLM (Case 7) has been developed in the context of a fisheries agency initiative (DFO Maritime in Atlantic Canada) and applies to fisheries within this jurisdiction. The EPI initiative (Case 8) is based on a defined policy context established by the New Zealand Department of Environment, and coordinates across a range of agencies, including the Ministry of Fisheries. The MSC (Case 10) is an independent non-government initiative that uses a market-based approach, encouraging the adoption of sustainable fisheries by awarding an eco-label that provides economic benefits.

From the cases a broad number of policy contexts that relate to fisheries management have been identified. Indicator systems can be used in virtually any given policy context, including national, regional and non-government jurisdictions. SIS are adaptable to the majority of policy approaches for managing or influencing fisheries management.

9.3.3 Jurisdiction

Jurisdiction is related to policy context, and refers to the relevant authority in terms of implementation and control over the direction of the SIS. The case studies are based in national, regional and non-government jurisdictions. Further examination reveals a diversity of responsibilities for the systems. An interesting feature is in the trend for agencies and organisations that have traditionally not been involved in fisheries management to become involved in the process. Benefits of this involvement can flow to management of fisheries, including increased transparency, accountability, public support and consensus. Indicator systems provide leverage for non-government organisations to provide pressure for fisheries reform and accountability.

The majority of the cases originate from national or sub-national government agencies or intergovernmental institutions. National and sub-national initiatives include SoE (Case 1), EPBC (Case 2), NEIS (Case 4), OBFM/MEQ (Case 6), TLM (Case 7), and EPI (Case 8). Intergovernmental approaches include NESDRF (Case 3) and NRTEE (Case 5). CCAMLR (Case 9) is based on an international treaty while the MSC approach is an independent, non-government institution. Regional, national and sub-national initiatives can directly affect management outcomes being tied to legislation and policy, while the intergovernmental and non-governmental initiatives seek to directly influence the management process.

9.3.4 Relationship to Fisheries Management

The ability of the SIS to relate to fisheries management planning is an important component of effectiveness. The SIS output should be used to inform decision-making and facilitate forward planning with the relationship between the SIS and the management articulated in the initial design.

The relationship to the fisheries management process is dependent on the policy and jurisdictional context of the indicator system. If an indicator system is tied to the management of a particular fishery, the results obtained from the SIS will feed directly into management outcomes and actions. Fisheries management is undergoing a transition to include broader ecosystem and socio-economic parameters into management. Indicator systems are a means to facilitate this transition.

The cases reveal a hierarchy of links to fisheries management. Cases that maintain no direct relationship include SoE (Case 1), NEIS (Case 4), and NRTEE (Case 5). These systems, as identified in 9.3.1, employ a generalised, educational and reporting function on the state of the resource. Their influence is primarily by indirect means through the political process. The next stage in the hierarchy is that of third party involvement in fisheries management. In these cases, external organisations that are not directly involved in the management of the resource can become involved through policy and legislative changes, external assessments, and market influences. The EPBC (Case 2), EPI (Case 8) and the MSC (Case 10) reflect third party involvement in the fisheries management process. The EPBC initiative conducts strategic assessment and approvals of Commonwealth and export fisheries management plans in Australia. The EPI case is a national environmental reporting and policy coordination tool, but has a process of feedback into ministerial decisions on total allowable catches and sustainability measures for New Zealand Fisheries. The MSC, as an independent non-government initiative, requires candidate fisheries to alter and improve their management arrangements to pass the certification process. The final scale in the hierarchy is cases directly involved in the management of the resource. These include the NESDRF (Case 3) which fosters a detailed voluntary approach by fisheries agencies on reporting, OBFM/MEQ (Case 6) that feeds directly into and forms the basis of fisheries management planning, TLM (Case 7) that is a part of the DFO stock assessment process, and CCAMLR (Case 9) that aims to generate decision rules for the Antarctic krill fishery.

9.3.5 Reporting Scale

To influence the fishery the SIS must adapt to context relevant fishery conditions and be meaningful to users and managers within the fishery. At the lower scale of reporting (i.e. local, provincial and sub-national) context sensitivity will encourage ownership, relevance and information input. As reporting moves to higher scales (national, regional and international) local relevance is reduced as broader indicators or indices are required for large-scale reporting. The literature suggests that context sensitive systems are the most useful for operationalising fisheries sustainability, but links to higher scale reporting systems are necessary for national and international assessments.

Reporting scale refers to the scale that the SIS reports on fishery units. The case studies display that in practice, indicator systems report at a variety of scales, from aggregate regional and national measures, economically important fisheries, gear based, and stock based assessments. The context sensitivity is directly related to the decision making scope, policy context and fisheries management relationship.

In terms of aggregate measures that are relatively context insensitive, the SoE (Case 1) and NRTEE (Case 5) fulfil this classification. The NRTEE initiative focuses on aggregate measures based on fisheries of economic and social importance. In addition, the NEIS (Case 4) focuses on fisheries of economic importance in its assessment. Cases that focus on stock and/or gear based assessments include the EPBC (Case 2), NESDRF (Case 3), OBFM/MEQ (Case 6), TLM (Case 7), EPI (Case 8), CCAMLR (Case 9), and MSC (Case 10).

9.3.6 Ecosystem Management Indicators

The categories above (see Table 30) identify the scope and application of indicator systems to fisheries cases from a strategic to an operational focus. The next set of components refers to the application of measurable indicators in fisheries management.

The sustainability of fisheries requires consideration of the ecosystem in which they operate. Ecosystem-based management (EBM) is an emerging concept within management that leads away from single stock management approaches to integrated ecosystem concerns and socio-economic influences. Significant advances in marine policy at an international and national level has focused on the need for an integrated approach that considers the effects of harvesting on the broader ecosystem and the effects of the ecosystem on the resource. A key issue is the practical implementation of EBM - developing a process and tools that can take EBM principles and apply them directly to fisheries management. Establishing an indicator system is seen as a step in this direction (FAO 1999a; Garcia 2000; Ward et al 2002).

This component (Table 30) refers to the development of ecosystem indicators in fisheries SIS. It asks the question: does the indicator system reflect EBM principles and set ecosystem criteria, indicators and performance measures? Ecosystem management indicators are the current focus of research in fisheries science and oceans management (Arbour et al 2001; Ward et al 2002) with demand growing in recent years with policy developments in all jurisdictions.

Across the case studies, the application of ecosystem management principles and indicators is irregular. Generally the principles of EBM are recognised at a strategic level, but translation into practice requires increased collaboration between scientists and policy makers, monitoring, and the application of new data sets. Investigation of the cases reveals a hierarchy of applications of principles and indicators.

The NEIS (Case 4) was an early attempt at environmental reporting in Canada, but focused specifically on target species indicators and did not include ecosystem references. Next in the hierarchy are cases that have recognised the value of an ecosystem-based approach, but are in the early stages of development of indicators. The SoE (Case 1), NRTEE (Case 5), and TLM (Case 7) fit into this classification. The SoE indicator system recognises and promotes an ecosystem approach and has developed indicators to measure the concept, but is hampered by a lack of information and monitoring. As a result this system uses proxies for interim measurement. The NRTEE recognises the advantages of monitoring ecosystems in management, but subject to information availability within its capital model, assesses habitat use and threatened species. Both indicators are in an early phase of development and are intended for future use. The TLM approach has applied a physical ecosystem indicator (ocean temperature) to several fisheries, and highlighted the exploration of ecosystem indicators to be added to its predominantly target based approach. The next hierarchy is cases that explicitly recognise EBM and include ecosystem indicators within their frameworks. Cases include EPBC (Case 2), NESDRF (Case 3), OBFM/MEQ (Case 6), EPI (Case 8), CCAMLR (Case 9) and MSC (Case 10). These cases maintain a diversity of methods for applying EBM indicators, ranging from subjective reporting systems (EPBC), defined ecosystem dimensions, criteria and indicators (NESDRF, MEQ, EPI, MSC), to ecosystem focused frameworks at the international level (CCAMLR).

EBM principles are recognised as a core dimension of fisheries management with indicator systems a tool for adapting these principles into practice. As the approaches evolve, the level of information on fisheries ecosystems, habitats and species will be included in sustainability assessments. Indicator systems can act as a means of priority setting for scientific monitoring programs and fill in the gaps in ecosystem research.

9.3.7 Target Species Indicators

Fisheries management, for its entire history, has been focused on managing target stocks. Management regimes have been built on the basis of monitoring the life-history characteristics of the stocks to include in population models [170] for stock assessments. These characteristics have included catch and effort data and biological data such as biomass estimates, recruitment, growth rates, reproduction rates and the rate of mortality. Once the population and its renewable capability can be estimated, the fishery can be managed on the basis of input (gear, effort, capacity) and output controls (Total Allowable Catches etc). The target species indicators within the SIS aim to tell managers if target species are being harvested and used in a sustainable manner. The indicators form a central part of management and should feedback to stakeholders and the management process. Using target species indicators within a broader indicator system is

[170] Maximum Sustainable Yield and Virtual Population Analysis are the predominant target species modelling approaches in fisheries management, expanded in Chapter 1.

a means of communicating the results of stock assessment and target issues more effectively and improving the overall process of management of the fishery.

All case studies contain target species indicators - the majority of scientific information collected on fisheries is based on the target species and their characteristics. A focus on the specific use of target species *indicators* (as opposed to stock assessments) can improve management by setting objectives, accounting for uncertainty, implementing performance measures, setting decision rules and establishing monitoring protocols. The presentation of complicated stock assessment data to stakeholders by the way of a simplified indicator approach can encourage stakeholder ownership and facilitate dialogue. An example is the application of the TLM (Case 7) to stock assessment in the Maritime region in Canada. The TLM is based on traditional assessment approaches, but has developed reference points and a visualisation strategy. Koeller et al (2000) documents how the application of TLM to northern shrimp stocks has resulted in improved management outcomes in the fishery. Target species indicators also contribute to communication of fisheries information to decision makers and the public. An example from the NRTEE (Case 5) is the aggregation of commercially important target species harvest data into an index that represents the sustainability of national fisheries. This index, as a part of the NRTEE Capital model output, could potentially used in socio-economic decision-making with other aggregate indicators. The use of the aggregated target species indicator takes the measurement out of the fishery, and directs it to a broader audience. The ongoing development and application of target species indicators contributes to the sustainable management of stocks and is an essential component of the SIS process.

9.3.8 Socio-economic Indicators

Sustainability is a human construct driven by socio-economic, political and cultural contexts within which the management of natural resources resides. The management of fisheries resources is expanding to consider the social and economic dimensions in which fisheries operations occur. Traditionally socio-economic and governance dimensions have been outside the scope of the biologically driven management process, despite these factors being an important influence on the fishery. Sustainability within fisheries covers new ground in the recognition of the socio-economic and the political factors that drive fisheries operations. More often than not, it is these influences that have driven the decisions on the regulation of a fishery, adjusting the level of catch, or recommending or halting the closure of a fishery.

Including socio-economic concerns into management is a task that remains to be undertaken. The challenges to implementing these concerns result not from a lack of data, but from a means of accessing, transforming, and coordinating data at a scale that is useful for management purposes. Indicator systems present a means to structure the objectives presented by socio-economic concerns into meaningful, scale-relevant operational objectives, indicators, and performance measures. Samples of socio-economic parameters can include (but are not limited to) direct and indirect employment generated by fishing, exports, social capital, services generated by fishing communities, safety issues, price at landing, generational involvement in the fishery, community values, governance of the fishery, and participation.

The case studies reveal that implementation of socio-economic concerns is at a developmental stage in fisheries management. Whereas the traditional focus has been on environmental aspects of fisheries (target, non target and ecosystem indicators) the advent of socio-economic measures is still to be fully realised. However research is progressing and attempts are being made. The SoE (Case 2), EPBC (Case 2), NEIS (Case 4), NRTEE (Case 5), TLM (Case 7), EPI (Case 8), CCAMLR (Case 9) have minimal or developmental programs for socio-economic and governance indicators. It should be noted that in this series of cases, the EPBC and EPI have developed basic governance indicators in the absence of socio-economic measures. The NRTEE has developed the broad dimension of produced and social capital, but these relate to broader societal measures and not to fisheries issues. The NESDRF (Case 3), OBFM/MEQ (Case 6), and the MSC (Case 10) have advanced socio-economic and governance indicator structures and are developing the means to measure, assess and incorporate these concerns into fisheries management.

9.3.9 Precaution and Uncertainty

Precautionary measures in the face of uncertainty have evolved as an accepted principle but remain limited in management practice. The variable nature of fisheries resources and stock assessment methods has resulted in uncertainty as an inherent feature of fisheries. In developing a precautionary approach to fisheries management a variety of methods have been described (Garcia 1994; Caddy 1998; Caddy 1999; Essington 2001). Generally, this follows the development of setting objectives, defining strategies to achieve them, setting targets and reference points, and generating a feedback process to cycle information back into the system (Halliday 2001; Ward et al 2002). Adopting a precautionary approach also involves the explicit identification, and if possible, quantification of uncertainty and error.

Indicator systems are a tool to assist fisheries in developing a precautionary approach. The very act of initiating an indicator system to expand management concern to account for a wider array of variables is a step in the implementation of the precautionary approach. The basic structure of the SIS in setting objectives, indicators and performance measures promotes consideration of uncertainty and a method to account for error within an adaptable management process. In addition the setting of indicators must follow a process of peer review, consultation, testing and feedback to minimise uncertainty. Cases that follow a basic recognition of the principal but do not pursue tools that assess uncertainty include the SoE (Case 1) and NEIS (Case 4). Cases that have recognised the principle and have developed measures to test indicators and account for information uncertainty include EPBC (Case 2), NESDRF (Case 3), NRTEE (Case 5), OBFM/MEQ (Case 6), TLM (Case 7), EPI (Case 8), CCAMLR (Case 9) and MSC (Case 10). Among these cases that implement the precautionary approach three innovative methods were identified. The NESDRF approach pursues a rigorous testing of component trees and indicators, reduces information uncertainty, and follows a process of formal risk assessment within the SIS to determine the priority issues for measurement. The TLM has been devised to specifically address uncertainty by setting reference points and values for stock variables that define acceptable and unacceptable outcomes. Reference points are intended to fit into defined decision rules for the fishery that initiate action when limit points are reached, though consensus is still out on the specific mechanism (Halliday et al 2001). The TLM maintains a comprehensive scientific peer review process that explicitly addresses uncertainty (Fanning 2002). The CCAMLR case study has evolved a quantitative approach for assessing uncertainty and a precautionary philosophy that embodies the consideration of uncertainty in data collection and process. The stock assessment process, directly related to the ecosystem program, establishes precautionary catch limits for krill that take into account the needs of the target and associated and dependent species (Nicol 1993; Nicol 1999).

9.3.10 Participation

Participation is an important consideration in the application of SIS to fisheries management. The selection and contribution to the framework and indicators facilitates an open and transparent process and encourages ownership and buy-in. Stakeholders can include, but are not restricted to, commercial, recreational, management, conservation, indigenous, tourism and community interests. Conflicts within the process can be resolved by dispute resolution, negotiation and consensus to prevent expensive litigation. Combination of top down and bottom up approaches are necessary for SIS success.

Participation also includes the input by a range of decision makers from jurisdictions relevant to the fishery. This ensures that the SIS maintains a link to policy development and action by the relevant authorities and encourages cross-sectoral and jurisdictional reporting, promoting an integrated approach. Participation by agencies in an indicator program can lead to improved coordination of policy across departments on marine and fisheries issues.

The case studies reveal a range of participatory approaches in SIS applications. SoE (Case 1), EPBC (Case 2), and NEIS (Case 4) maintain a primarily top down reporting processes with minimum participation of stakeholders. These systems do consult with stakeholders during their development and implementation, but overall *participation* remains low in terms of ongoing input and feedback. These systems are generally single agency initiatives and do not feed into broader decision making processes. The NESDRF (Case 3), OBFM/MEQ (Case 6), and CCAMLR (Case 9) systems represent initiatives where stakeholder participation is achieved and participation by agencies is growing. The NRTEE (Case 5), TLM (Case 7), EPI (Case 8), and MSC (Case 10) all display diverse models of stakeholder and agency participation which can provide useful models for future development.

9.3.11 Status

The status component simply refers to the current state of development of the indicator system in relation to fisheries assessments. The status is current as of September 2003. Analysis of the case studies reveals several SIS are in a developmental research and pilot stage whilst other cases are maturing and being applied directly to fisheries management.

Cases that are in an early to mid stage of development or are still developing indicators include the SoE (Case 1), NESDRF (Case 3), NTREE (Case 5), OBFM/MEQ (Case 6) and CCAMLR (Case 9). Cases that are applying indicator sets to actual fisheries, creating outputs, and are using the results in management include the EPBC (Case 2), TLM (Case 7), EPI (Case 8) and the MSC (Case 10). The NEIS (Case 4) has effectively been superseded by other initiatives but provided an important basis for development of indicator-based fisheries reporting.

9.4 Objective 3: Common SIS outcomes.

Objective 3 assesses the comparative performance, roles and outcomes of sustainability indicator systems across fisheries jurisdictions. It seeks to answer the question of indicators providing a mechanism or tool for the implementation of sustainability into management practice. It seeks to obtain insight into the use of SIS across fisheries management jurisdictions.

Addressing this aim follows two approaches. The first is to compare the performance of the case studies through the outcomes gained by the assessment framework. To compare the performance of the SIS cases across all jurisdictions the outputs from the orientation graphs and the Dashboard Model software has been employed. This software enables each SIS to be aggregated and compared on the basis of the score obtained in the assessment framework to an overall Policy Performance Index (PPI). The SIS are ranked according to their respective PPI. In addition the SIS can be ranked according to the sub-criteria or different weightings can be explored (see below). The Dashboard model allocates performance colours to enable clear communication of the information. This is similar to the method employed by the TLM (Case 7) to enable communication and comparison of indicator data. It is important to note that this method of analysis focuses on the comparison of *indicator systems* as based on the *assessment framework*. It does not attempt to directly compare or rate the performance of countries and jurisdictions with complex underlying socio-political factors. The focus is on looking at the positive and negative aspects of the cases examined and what lessons can be gained for improved SIS development.

The second approach to address Objective 3 is to distil the empirical information from the case studies and the assessment framework that reflects positive fisheries sustainability and management outcomes generated by SIS. The identified outcomes include:

- Indicator systems facilitate scientific and policy coordination;
- Indicator systems inform stakeholder and community organisations;
- Indicator systems facilitate co-management of fisheries systems;
- Indicator systems facilitate transparency and accountability in decision-making;
- Indicator systems contribute to the implementation of ecosystem based management and precautionary approaches;
- Indicator systems are used as a tool for increased external environmental agency involvement in fisheries management;
- Indicator systems facilitate increased participation in and awareness of fisheries management mechanisms by NGO bodies and the public;
- Indicator systems are forming the basis of management and performance measurement standards;
- Indicators expand the fisheries ‘equation’ and account for critical broader influences.

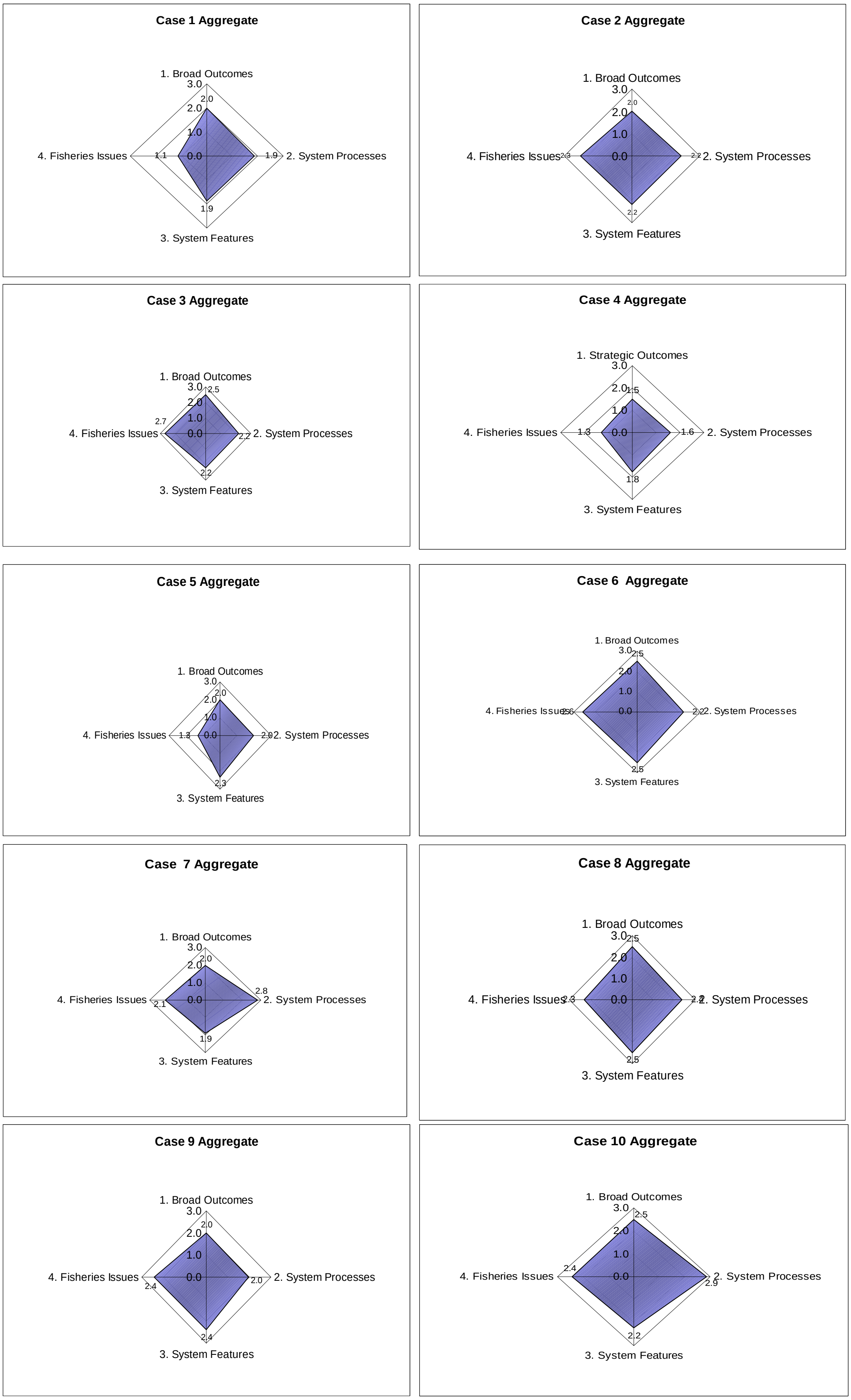
9.4.1 Case Study Aggregates

In each case study analysis a series of orientation graphs were developed. The graphs show the ‘pattern’ of each sustainability indicator system, according to the scores allocated via the assessment framework. A case aggregate orientation graph was developed that displayed the overall performance of the SIS against the Strategic Criteria of the framework. These graphs have been reproduced below in Figure 63. The advantage of using the orientation graphs is that they provide an informative visual analysis of the SIS against the framework. The graphs also allow for a visual inspection of the performance across the cases. While the actual shape of the graph is the result of an arithmetic averaging process, the shapes reveal the key aspects of each system.

The orientation results are discussed in detail in each case study but a comparative summary is provided here. Case 1 clearly relates to the SIS being focused as a broad reporting tool that covers a wide range of issues. It has average scores in Broad Outcomes, System Processes, and System Features but a low score in Fisheries Issues. Case 2 displays an overall balanced SIS with an above average score in all four strategic criteria, and a tendency towards strong Fisheries Issues. Case 3 performs well with a strong scoring in all strategic criteria. In particular Case 3 has a very strong approach towards assessing fisheries issues, a model SIS. On the opposite, Case 4 scores weakly in across the Strategic Criteria, but this can be attributed to the early developmental nature of the SIS. Case 5 is focused towards Outcomes and System Features - a result of the integrative nature of the SIS. However it falls short of achieving in Fisheries Issues, an area for future improvement. Case 6 is a very strong system across all Strategic Criteria and can be considered a best practice approach. Case 7 is highly skewed towards System Processes – the structure of the SIS is innovative and effective, yet it needs to improve on its integration and fisheries issues. Case 8 also scores highly across the all Strategic Criteria, a balanced, effective SIS and a model approach. Case 9 scores above average in all criteria with a focus towards Fisheries Issues and System Features - a well resourced, participatory and fisheries focused approach. Case 10 is the highest scoring system with high scores in all Strategic Criteria. In particular is has a rigorous Systems process, effective and balanced outcomes, and a focus on sustainable fisheries. This system is truly a best practice and innovative approach.

For investigating the comparative performance in detail of the overall systems, the Strategic Criteria, Sub-criteria and weighted criteria the Dashboard software has been employed.

Figure 63. The Case Study Aggregates



9.4.2 Comparative analysis of the Case Studies and the Dashboard Model.

In order to compare across jurisdictions and rank the overall relative performance of the case studies the Dashboard Model software has been utilised. While the aggregate orientation graphs above allow for an overall 'snapshot' of performance, the Dashboard allows for detailed comparative analysis and performance ranking, weighting of criteria and investigation of relative strengths and weaknesses of the SIS.

The Dashboard Model is a visualisation tool that converts indicator data into standardised scores and indices, and presents information in the form of graphic dashboard – similar to the dashboard of a car. It recognises the need to simplify large lists of complex measures into simpler aggregated measures using innovative visualisation techniques that aid in decision-making (CGSDI 2002). The Dashboard has been adapted for identification of the strengths and weaknesses within individual indicator sets, comparing between the cases, and assessing performance of the cases based on rankings.

An example of a sustainability assessment with the Dashboard Model is displayed in Figure 64. The figure highlights a series of individual indicators on the outside ring, based on the dimensions of environment, economy and social care. These scores are normalised to and averaged to obtain an aggregated score for each dimension.[171] The scores in the middle of the Dashboard circles (the Policy Performance Index) are obtained by averaging the scores of each dimension.

Three important methodological issues are considered when observing Figure 64:

- The size of a segment reflects the relative importance of the issue described by the indicator;
- A colour code signals indicator performance <u>relative to others</u>: green means "good", red means "bad";
- The central circle (PPI, Policy Performance Index) summarizes the information of the component indicators.

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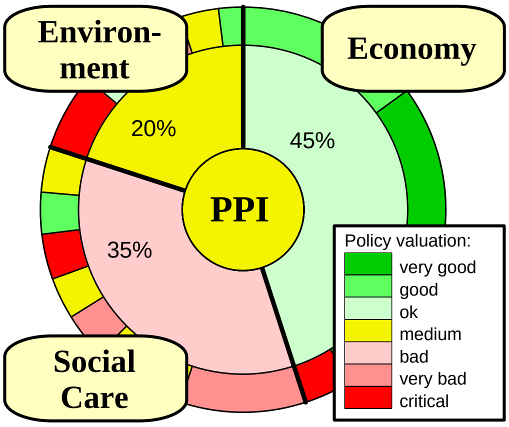
[171] A drawback of the existing model is that it is limited to aggregating to two levels, as shown in Figure 64.

Figure 64. The Output of the Dashboard Model (adapted from (Jessinghaus 2003)).



For each indicator, a normalised point score is calculated out of 1000. Point values are linearly interpolated between the worst (0 points) and the best scores (1000 points) (CGSDI 2002). The Dashboard assumes equal weighting for all scores, but a feature of the model allows for weightings to be manipulated according to policy priorities. This thesis examines criteria at equal weightings and with manipulated weightings. The aggregate score is obtained by averaging the indicators. This is done for all components, and then each component is aggregated to form the overall Policy Performance Index (PPI).

A colour is applied to the score based on its ranking relative to the scores within that indicator set. The allocation of the colour depends on the position of the indicator or aggregated component in the database (that is, the valuation is relative to the position of the score). Performance is displayed through a seven-colour code ranging from dark red (a 'bad' score) to yellow ('average score') to dark green ('best' score). This colour coding can provide for rapid assimilation of performance at each scale of the assessment. Each case study was scored against the assessment framework and aggregated (via averaging) to the strategic criteria level. A summary of the case aggregates is provided below in figure 65.

Three analyses have been performed with the Dashboard: 1) a ranking on an overall SIS performance based on equal Strategic Criteria forming the PPI; 2) a ranking on Fisheries Issues sub-criteria only, and 3) a ranking based on a weighted PPI. The performance valuations and the PPI rankings for the case studies are displayed below.

Figure 65 SIS Case Study Performance Valuations and Policy Performance Index

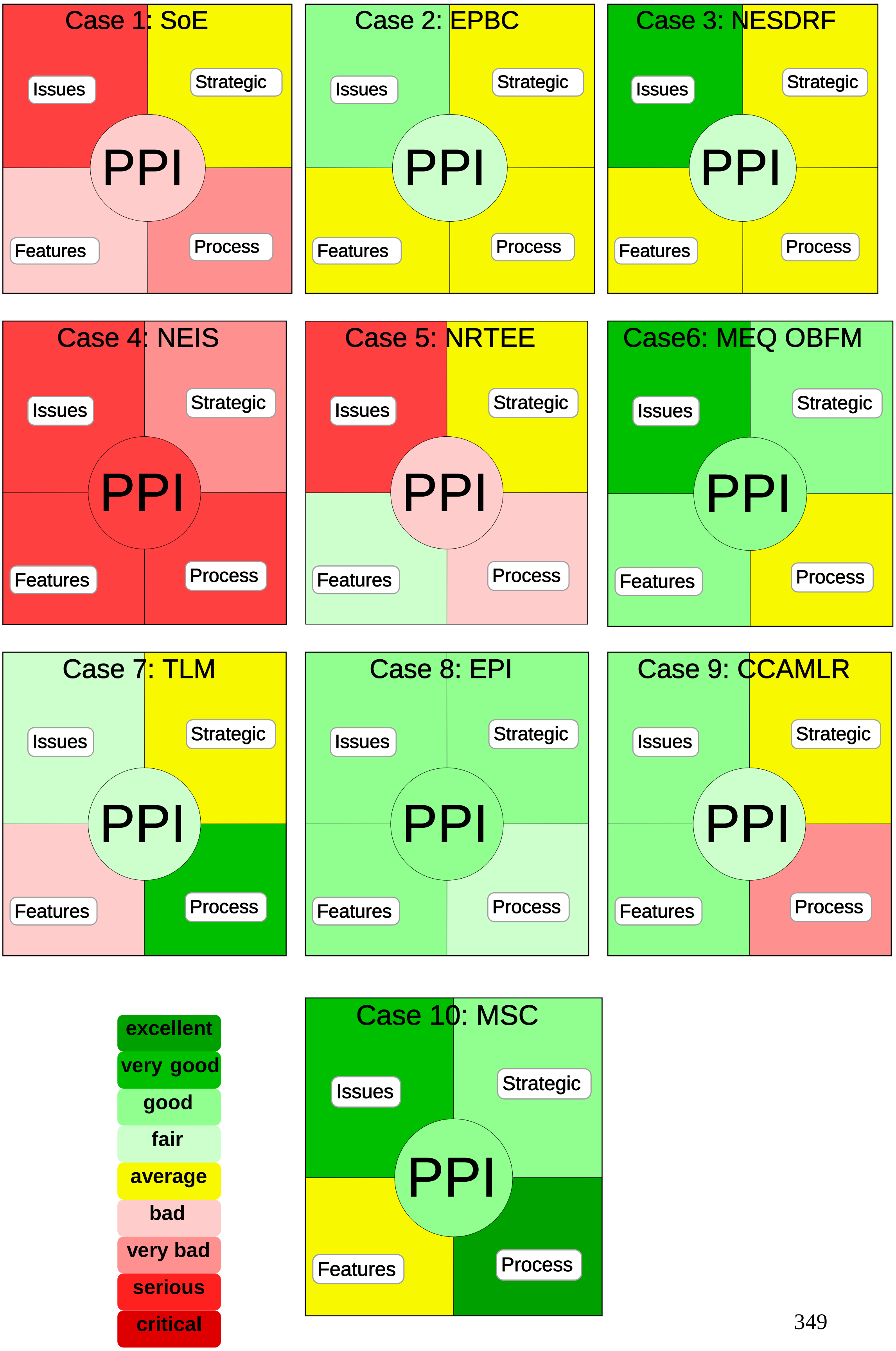


Table 31. Policy Performance Index Rankings.

Rank	Points	Country
1	741	Case 10: MSC
2	702	Case 6: MEQ/OBFM
3	700	Case 8: EPI
4	592	Case 7: TLM
5	586	Case 3: NESDRF
6	585	Case 9: CCAMLR
7	559	Case 2: EPBC
8	440	Case 5: NRTEE
9	336	Case 1: SoE
10	203	Case 4: NEIS

The highest-ranking indicator system is the MSC (Case 10). The MSC scores a PPI of 741 points, placing it in the good category. Examination of the MSC assessment criteria reveals that an excellent score in the system processes and a very good score in fisheries issues achieve the PPI top rank. A good score is obtained in the strategic outcomes of the SIS and an average score in system features. Significant improvement of issues under the system features component will increase the PPI of the MSC program. At 2nd rank is the OBFM/MEQ indicator system (Case 6) with a good PPI of 702 points. This system obtains an excellent score in fisheries issues and a good score in strategic outcomes and system features. An average score is obtained under system process. Improvements to the SIS input and output processes will improve the score of the PPI. This case is closely followed by the EPI program (Case 8) at 3rd rank with a PPI score of 700 points and a rating of good. The PPI consists of good scores in strategic outcomes, system features and fisheries issues, and has obtained a fair score in system processes. The three highest ranked indicator systems, all grouped around the 700-point mark and based in the good category, contained components that were all above average and therefore contributed an overall high index.

The next set of indicator systems has been assessed with a fair PPI ranking and has achieved range of scores within the 500 point range. These SIS have generally scored above average in most components, but a low score in one or series of averages has reduced the overall PPI. The TLM (Case 7) is ranked 4th with 592 points. The TLM obtains a very good score in system processes component indicating an effective structure. Fisheries issues obtain a fair result whilst strategic outcomes get an average result and system features a bad result. At 5th rank with 586 points is the NESDRF initiative (Case 3). The NESDRF obtains a very good valuation in fisheries issues, and average result in the other strategic components. At 6th rank, CCAMLR case obtains a PPI of 585 points and is classified as an average performance. CCAMLR (Case 9) obtains a good score in fisheries issues and system features, an average score in strategic outcomes, and a bad result in system processes. This would result primarily from the developmental nature of the indicators and performance measures in the SIS. Future work on structuring the CEMP information will lead to an improved overall PPI. At 7th rank is the EPBC with 559 points. The SIS has a good score in fisheries issues, but average scores in the other strategic criteria – leading to an overall fair result.

At the lower end of the performance valuations, the NRTEE (Case 5) obtains a PPI of 440, classified as a bad result. A fair score was obtained for system features, average score was obtained for strategic outcomes, a bad score for process and a serious result for fisheries issues, leaving room for significant improvement in this component. SoE case obtains a PPI of 336 points, which is classified as serious. The SIS obtains an average score in strategic outcomes and a bad score in system features and processes The SoE initiative (Case 1) has identified a range of indicators but suffers from a lack of information and coordination. Future efforts to improve the information basis will dramatically improve the PPI. The NEIS (Case 4) obtains a PPI of 203, with consistently below average scores in all components. However, this result is not surprising considering the early developmental nature of the SIS.

While the ranking in Figure 65 focuses on an aggregate Policy Performance Index, the Dashboard model allows for a ranking to be performed on any of the sub-components. An alternative approach to examining outcomes for fisheries SIS is to directly rank the cases on performance in the Fisheries Issues component. While the Strategic Outcomes, System Processes and System Features are generic components and apply to any SIS, Fisheries Issues relate directly to fisheries management issues. It assesses the implementation of ecosystem-based management principles, target species indicators, uncertainty and precaution, relationship to fisheries management, static vs. dynamic reporting, contextual issues and external issues. Figure 66 and Table 32 below examine dashboard results under the Fisheries Issues component.

Figure 66. SIS Case Studies Performance Valuations for Fisheries Issues

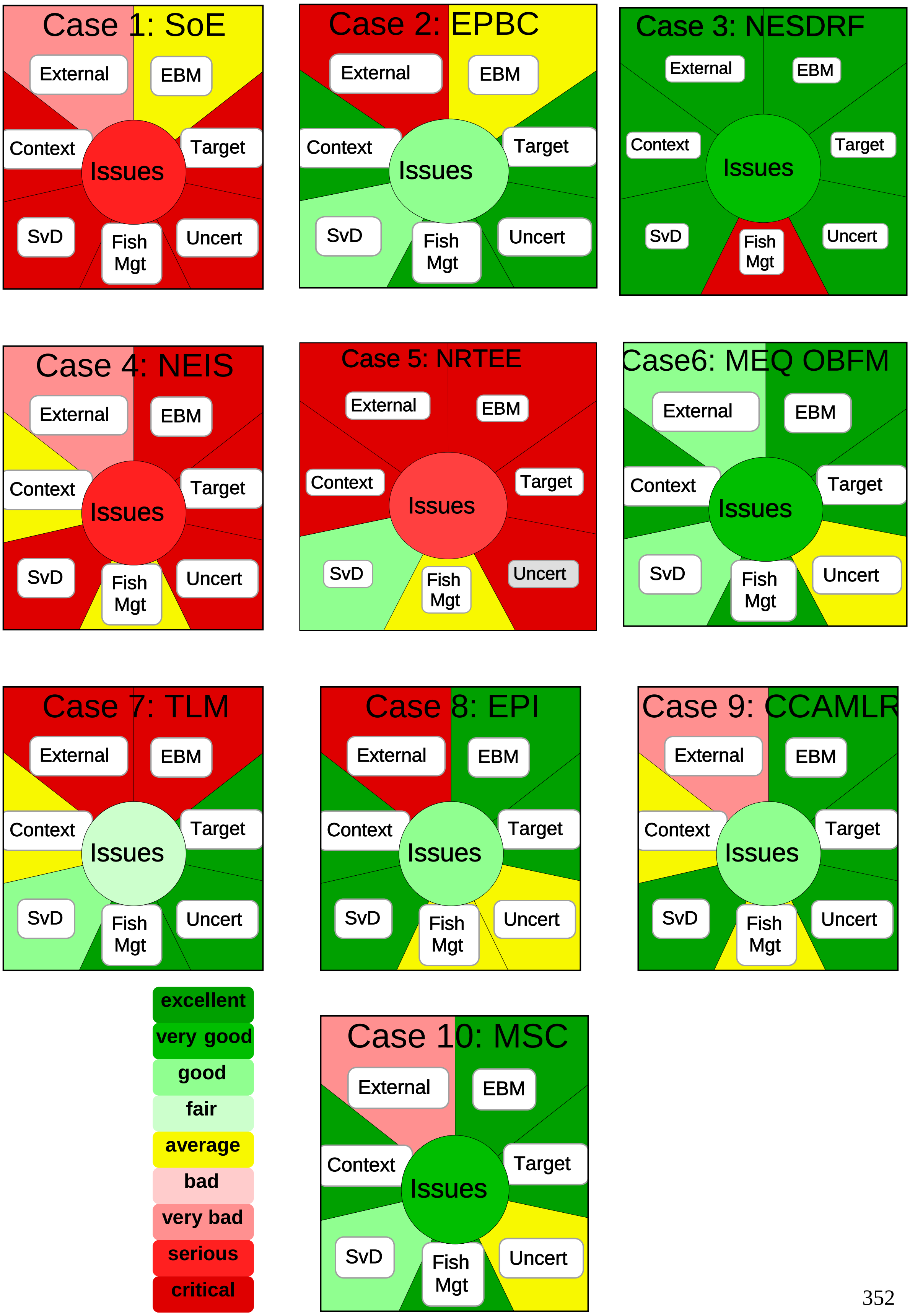


Table 32. Fisheries Issues Scores and Rankings.

Rank	Points	Country
1	857	Case 3: NESDRF
2	833	Case 6: MEQ/OBFM
3	785	Case 10: MSC
4	761	Case 9: CCAMLR
5	738	Case 2: EPBC
6	714	Case 8: EPI
7	595	Case 7: TLM
8	190	Case 4: NEIS
9	166	Case 5: NRTEE
10	119	Case 1: SoE

Observing the rankings under the aggregated PPI and Fisheries Issues reveals a significant difference in the results and a shift in rankings. Several cases that have performed well in the aggregate PPI have been ranked lower in Fisheries Issues, and conversely, cases that have scored lower in the overall PPI have been ranked higher under fisheries issues. This demonstrates that the perceived effectiveness of an indicator system can depend on a variety of factors.

Examination of the fisheries issues rankings reveals that majority of cases score in the range of fair to very good (Figure 66). The Obtaining a score of 857 points, the NESDRF (Case 3) is placed at 1st rank and classified as very good in terms of addressing fisheries issues with excellent scores in majority of fishery issues criteria. The relationship to management is an area for significant improvement (at this point in time the SIS has been pilot tested in several fisheries). At 2nd rank, the MEQ/OBFM initiative (Case 6) obtains a score of 833 and is described as very good. The SIS obtains a mix of high and above average results in all criteria. At 3rd rank with 785 points is the MSC initiative. The SIS scores above average in EBM, target, management and context components, an average score in uncertainty and below average score in external issues. The CCAMLR initiative (Case 9) obtains 4th rank with 761 points. High scores are obtained for EBM, target, uncertainty and dynamic reporting, average scores for management and context issues, and below average for external issues. The EPBC (Case 2) obtains 5th rank with a good score of 738 points. High and above average results are obtained for target, uncertainty, management context and reporting components. An average score for EBM and below average score for external issues results in an overall good result. Following close behind, the EPI initiative (Case 8) obtains 6th rank with 714 points. There is a slight drop in scores to 7th rank, with the TLM initiative (Case 7) obtaining a score of 595 and ranked as fair. The TLM scores high in the target, uncertainty and management criteria. However, the overall score is brought down by poor performance in the EBM and external issues components. Improvements in these components will improve the operation of the SIS.

The ranks and dashboards for the NEIS (Case 4), NRTEE (Case 5), and SoE (Case 1) indicate that the SIS do not perform well in the Fisheries Issues criteria. The dashboards highlight a relatively poor performance in all fisheries components, with a predominant display of yellow and red performance ranks. It should be noted however that these SIS aim to inform the general public about broad environmental issues across a spectrum of sectors and are not specifically designed for fisheries management applications, despite containing a significant fisheries component.

This outcome highlights an issue in the interpretation of aggregated indices - while they are inherently useful in terms of generating a broad overview and summary of multiple jurisdictions and issues, they can conceal significant and meaningful results at lower scales that have important policy implications. Any interpretation of an aggregate score must include a breakdown of the results into lower order indicators to avoid the risk of over-generalisation and misinterpretation. For example in Figure 65 the MEQ (Case 6) and the EPI (Case 8) obtain very similar results in the PPI but are based on very different component scores. Despite a similar overall rank, the policy response to improving the systems would be quite different. This issue is common to all indicator systems – the aggregated scores are useful for broad policy observation, communication and analysis but the lower hierarchy components are necessary for detail. The dashboard method enables both to be simultaneously observed.

The first set of dashboard comparisons in Figure 65 used the approach where all criteria were deemed equal for the calculation of the overall PPI. In this analysis each strategic criteria was weighted at 25% towards the PPI total. In addition Figure 66 displayed the ranking of SIS cases solely on the basis of the Fisheries Issues strategic criteria. This leaves a gap in the analysis – the comparative rankings of the SIS based on a weighted PPI. To assign a weight to a criteria is a controversial choice, but by the nature of this thesis, performing on fisheries issues can be considered a key requisite for the SIS cases, and therefore an analysis of a weighted PPI based on fisheries issues is justified. The outcomes of this analysis are presented in Figure 67 and Table 33 below.

Figure 67. Dashboard Rankings with a Fisheries Issues weighted PPI.

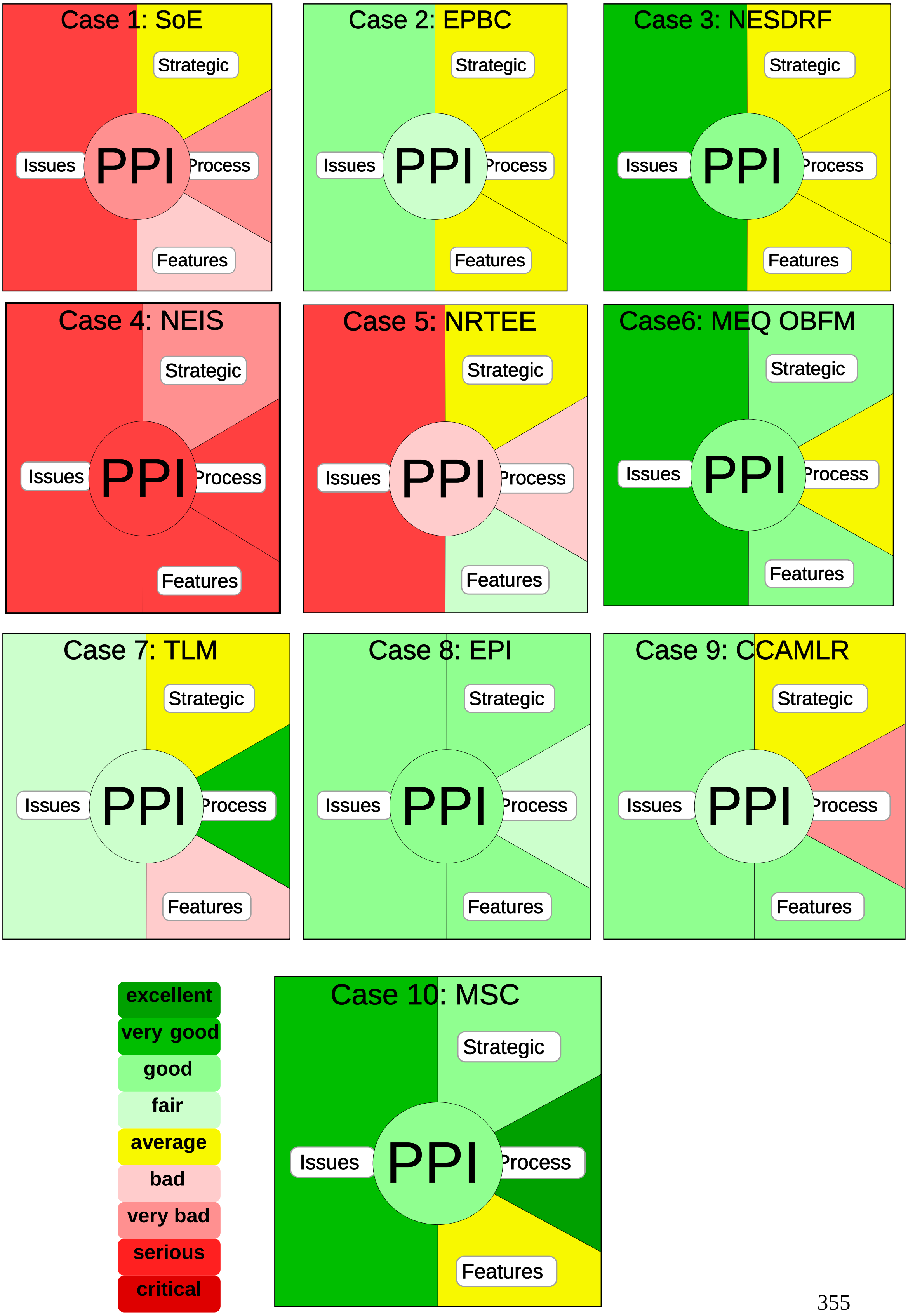


Table 33 Weighted PPI Scores and Ranks

Rank	Points	Country
1	756	Case 10: MSC
2	745	Case6: MEQ OBFM
3	704	Case 8: EPI
4	676	Case 3: NESDRF
5	643	Case 9: CCAMLR
6	619	Case 2: EPBC
7	593	Case 7: TLM
8	349	Case 5: NRTEE
9	264	Case 1: SoE
10	199	Case 4: NEIS

An advantage of the Dashboard model is the ability to examine different criteria weightings that form the PPI. In this analysis the contribution of fisheries issues to the overall PPI is considered the predominant weighting while the other criteria, while still important, assume a lower contribution to the PPI. Correspondingly Fisheries Issues are weighted at 50% and the other 3 strategic criteria at 16.6% (Figure 67).

Despite the dashboard colour allocations remaining relatively the same (i.e., the case being within the same performance band) there were significant shifts in scores and ranking compared to the equal weighting approach. The PPI scores for fisheries indicator systems that performed well in the fisheries relevant issues all significantly rose. In comparison with Table 31, while the rankings for Case 10 (MSC), Case 6 (MEQ/OBFM) and Case 8 (EPI) stayed the top 3 positions, the scores increased. Case 10 scored 756 points as the comparatively best performing SIS, with Case 6 also scoring highly at 745 points. Case 10 scores very good in Fisheries Issues (leading to an overall better PPI), very good in System Processes, good in Strategic Outcomes and average in System features – overall an effective indicator system. Case 6 also scores very well in Fisheries Issues, good in Strategic Outcomes and System Features and average in System Process leading to an effective SIS. It is interesting to note that the 3rd rank Case 8 (EPI) stays the same in the equal weightings (a score of 700 in Figure 61) and in the weighted PPI with 704. In Fisheries Issues this case is ranked lower at 7th but due to consistent high scores in Strategic Outcomes, System Features and System Processes the SIS remains at an overall 3rd rank. The

SIS has a highly integrative nature across a variety of issues, and strong indicator development and capacity.

The middle-order rankings have changed significantly with the fisheries orientated policy performance index. Case 3 (NESDRF) while initially at 5th rank in the equal weightings at 586 points jumped to 4th rank with 676 points, directly due to the excellent consideration of most fisheries issues (see Figure 66). CCAMLR rose from 6th ranking (585 points) in the equal weightings PPI to 5th rank in the weighted set, also due to a high Fisheries Issues score. Case 2 (EPBC) also moved up a place to 6th rank and 619 points. Case 7 (TLM) was ranked in 7th position (593 points) in the weighted PPI despite a 4th ranking in the equal weights set (Table 31). This was due to a fair score in fisheries issues (Figure 66, Table 32). With improvements in ecosystem based and external measures this SIS will be very effective when combined with the high scoring in System Process.

The lower level rankings in the weighted PPI remained the same as the equal weighting PPI. However the scores in the weighted set were slightly lower (Table 33). It is important to note that this does not imply overall ineffective or poorly designed systems. The implications are that in the SIS that have a broad assessment approach to environmental issues, there is significant room for improvement of fisheries measures and integration.

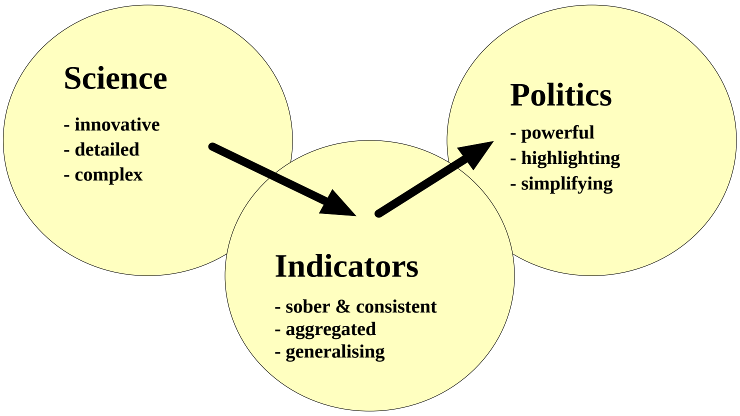
Generating the PPI and ranking the indicator systems is a useful analytical tool to evaluate policy effectiveness. Ranking and comparison enables a ‘state of play’ to be observed for the global development of indicator systems from diverse socio-economic and political jurisdictions. It highlights the relative strengths and weaknesses of each system and facilitates visual comparison of other efforts leading to insight and improvement for systems as a whole. It should be noted however that each case is a complex system that achieves outcomes within its own policy context and interpretation should take into account any underlying contextual issues.

9.4.2 Common Outcomes for Fisheries Sustainability Indicator Systems.

1. Indicator systems facilitate science and policy coordination and cooperation.

The use of indicator systems in fisheries management moves towards increasingly integrated scientific monitoring and development of policy advice. Scientific information provides the information that underpins effective decisions on natural resource management, but the communication between science and politics is a complex process, based on differing conceptual frameworks and measurement systems. Figure 68 below distinguishes between science as innovative, detailed and complex while politics displays the characteristics of being powerful, highlighting and simplifying (Jesinghaus 1999). This is clearly an oversimplification but it does highlight the issue of coordination that is a problem in decision-making regimes. Indicators provide a focus and compromise between the scientific and policy spheres, and transform large amounts of scientific data into pragmatic and decision-relevant information. Scientific data is clearly important and necessary. Improved decision-making occurs when “politics” engages with the “science”.

Figure 68. The Relationship between Science, Politics and Indicators.



Adapted from (Jessinghaus 1999).

Scientific and policy coordination comes into play at all levels of the indicator system process. The setting of the framework and definition is based on a policy decision but uses scientific methods to elaborate the dimensions and criteria. For example, the TLM (Case 7) is based on a decision to incorporate a precautionary approach, and uses biological characteristics to establish indicators and measurements. The MEQ/OBFM (Case 6) approach is based on a policy decision to develop objectives based fisheries management, with the MEQ framework specifically based on ecological criteria.

The setting of objectives (based on policy requirements) and related indicators and performance measures (based on scientific measures) is another example of policy and scientific integration. All SIS cases display processes where scientific studies (biological, ecological and social) provide the foundation for measurable and repeatable indicators. In addition indicator systems provide a means of direction and coordination for ongoing scientific research to meet key policy and management criteria. The EPI process (Case 8) is an example where government departments and their scientific research programs are tasked with the development of relevant indicators and the coordination of research (the Ministry of Fisheries provides data from fisheries management into the EPI program marine indicators). Often the indicator system will highlight the priority areas for research and information and may assist in setting future research priorities. The type 1 and 2 indicators from Case 8 are a good example.

2. Indicator systems inform stakeholders and the community.

Indicator systems are a means by which complex management information, in all its forms, can be reduced in complexity to inform stakeholders and the community. Indicators summarise the biological, ecological, socio-economic and governance aspects of the fishery, with ongoing monitoring of these variables informing stakeholders of performance over time. Fisheries management is a multifaceted process, conducted in a climate of scientific uncertainty with political and socio-economic influences. Any means to include stakeholder and community organisations in decision-making processes, improve consultation mechanisms, or inform the public of the state and performance of the fishery will require simplified and improved communication of all relevant information. Several indicator systems specifically inform stakeholders of relevant operational issues within the fishery. These include the EPBC (Case 2), NESDRF (Case 3), MEQ/OBFM (Case 6) and TLM (Case 7) systems. A number of SIS directly fulfil the role of national reporting of environmental issues in fisheries. The SoE (Case 1), NEIS (Case 4), NRTEE (Case 5) and EPI (Case 8) initiatives contain as a part of their aims and structures mechanisms to improve the flow of information to the community and clarify important issues. These indicator systems focus upon generalised information (e.g. total caches of commercially important species per year) and avoid detailed assessments. The TLM has had particular success in informing fishery stakeholders and achieving management consensus, particularly in the northern Atlantic shrimp fisheries (Koeller et al 2000; Fanning 2002).

3. Indicator systems facilitate the co-management of fisheries resources.

Co-management refers to the increased participation of industry in making decisions about the fishery. Co-management involves the sharing of decision power, responsibility, and risk between governments and stakeholders (DFO 1999b; Haward 1999). Building co-management approaches provides benefits such as shared responsibility, ownership of the resource, transparency, participation, and cost saving (DFO 1999a; Canada 1999b). Although indicator systems do not implement co-management by themselves (this requires further legislative and policy development) it is a vehicle via which stakeholders can contribute to the overall management process – setting objectives, contributing to indicators, and implementing monitoring programs. Furthermore, indicator based results can be brought to the decision table and presented for discussion. If the SIS has an established reporting, communication and visualisation strategy, information flows to stakeholders will be improved, and co-management facilitated. Indicators can also be used to measure the success of program delivery under co-management. Several cases have aligned themselves with developing a co-management approach. The NESDRF (Case 3) is primarily an industry and agency driven process and is linked to developing improved sustainability reporting mechanisms. The OBFM initiative (Case 6) aims to increase participation and responsibility and set objectives that assess the performance of the fishery plan (National Policy Committee 2001). The TLM (Case 7) demonstrates how the outputs of an SIS can facilitate improved understanding of and participation in the stock assessment process. Through the generation of clear stock status signals over time, stakeholders are able to participate in assessment and allocation decisions.

4. Indicator systems facilitate transparency and accountability in decision-making.

Indicator systems are the basis of assessing progress towards sustainable development and implementing ecosystem based management within fisheries. As noted in (FAO 1999a) indicators track progress, predict and warn about potential problems, facilitate learning by comparison between fisheries, and inform policy. When observing indicators, it should be possible to condense the complexity of a system to a manageable amount of meaningful information that assists the users in informing progress and making decisions (Bossel 1999). Although indicators do not replace the conventional information that is used to manage fisheries systems, they enable this information to be presented and communicated in a clear format to stakeholders and highlight the basis of decisions or particular courses of action.

The use of indicator systems enables the methods and data, which are the basis of management decisions, to be available for scrutiny by stakeholders. Through the SIS structure the framework for the assessment and the objectives for the fishery are made explicit, as are the means of obtaining them and measuring progress. The outputs of the SIS, which include the interpretation, analysis and conclusions, are communicated to those who have an interest in the fishery and the broader public, and as a result the transparency and accountability of decisions are increased (for example, TAC decisions or regulation of activity). The reporting of indicator results opens up the basis of management through the medium of working groups or management committees, and can increase stakeholder support for the fishery as a result of this increased transparency.

Several cases directly address transparency and accountability issues in fisheries decision-making. The EPBC process (Case 2), NESDRF (Case 3), MEQ/OBFM (Case 6), TLM (Case 7), EPI (Case 8), and the MSC (Case 10) all broaden the traditional notion of fisheries management to include environmental and socio-economic measures, and include conventional fisheries information such as target stock assessments. Each process involves the increased participation of and reporting to stakeholders, mechanisms to directly report to the public (including dynamic web based reporting), and aims to generate a transparent process that involves the target audience and public reporting.

5. Indicator systems contribute to the implementation of ecosystem based management approaches.

In recent years policy developments have expanded to include the notion of ecosystem-based management. This is particularly acute in the development of Oceans Policy regimes that espouse integrated and ecosystem-based management approaches for the broader marine environment. Within fisheries, EBM directly calls for the expansion of target species based management to include broader ecosystem concerns, including the effects of the physical ecosystem on the fishery, the effects of harvesting on associated and dependent species, and the effects on habitats and communities. EBM has expanded to consider the effects of human (socio-economic) factors within the fishery as these issues directly relate to management success or failure, particularly in regard to the implementation of ecosystem-based regulations.

Indicator systems have been identified as one of the primary tools to implement the EBM process through the establishment of reporting structures, identification of strategic principles and objectives, development of specific indicators and performance measures, and establishing decision rules that feed back into fisheries management. The cases reveal that EBM is a driving force behind the establishment of indicators as traditional management systems expand to implement the concept. Examination of the cases and empirical information reveals that EBM occupies a strategic position in terms of setting the guiding principles and objectives, but the implementation via criteria, indicators and reference points is still in a developmental stage. Indicator systems including EPBC (Case 2), NESDRF (Case 3), MEQ/OBFM (Case 6), EPI (Case 8), CCAMLR (Case 9) and the MSC (Case 10) provide relatively advanced examples of EBM implementation into management within national, international and non-government jurisdictions. Valuable practical lessons on incorporating EBM into fisheries can be gained from these cases, including the setting of measurement frameworks, translation of principles to specific measures, establishing reference points, reporting and visualisation outputs, and stakeholder engagement. It is the transmission of these success stories that will provide a foundation for increased uptake of ecosystem-based management practice.

6. Indicator systems contribute to the implementation of precautionary approaches.

The precautionary principle was officially recognised in the Code of Conduct for Responsible Fisheries 1995 and under the binding UN Conference on Straddling Stocks and Highly Migratory Fish Stocks in 1995 (Fanning 2002). Precautionary measures have evolved in the face of increased uncertainty in the management process and assessment of fisheries resources. It has evolved as an accepted principle, having been included in a variety of national and international legal and policy documents, but generally remains limited in term of developing specific processes and mechanisms in management. A precautionary approach, in its most basic form involves 'erring on the side of caution' when making decisions in a climate of uncertainty, but methods to implement this approach have been lacking or superseded by political pressure to maintain harvests. Initial methods focus on the identification and development of reference points (target and limit thresholds) for fisheries that identify desired states (targets) or undesirable states (limits) (Caddy 1999; Essington 2001). Establishing a precautionary approach has now evolved in terms of the development of an entire adaptable management process to account for uncertainty (and quantify it if possible) and adjust the management system to minimise risk of long term detrimental impacts. This includes setting objectives, strategies, targets, reference points, and decision rules to cycle information back into management.

The process of constructing indicator systems facilitates an approach to addressing uncertainty. Despite the lack of practical precautionary approaches in fisheries management systems, the inherent structure of an indicator system aids the development of a precautionary approach. Several cases have addressed the issue of uncertainty and precaution within their structures, in particular NESDRF (Case 3), TLM (Case 7) and CCAMLR (Case 9). These cases have developed advanced approaches that quantify, assess and communicate information uncertainty and propose mechanisms for feedback management. Fisheries systems can learn valuable lessons and methods from these cases in implementing a precautionary approach.

7. Indicator systems are used as a tool for increased environmental agency involvement in fisheries management.

Examination of the cases has revealed a trend of increasing involvement of government environmental agencies in the traditional management of marine fisheries resources. This role is in the form of direct regulatory involvement in the fishery and/or influence in the management process and has provided some controversy over management jurisdiction.

The development of broad integrative oceans policies across national jurisdictions has increased public awareness of and management initiatives within the marine environment. The oceans policy initiatives, particularly from Australia, Canada, New Zealand and the USA, have generated inter-departmental and inter-sectoral reporting and assessment requirements, moving towards the integrated management of marine resources. Indicator systems have been developed within oceans policy programs as tools to monitor and assess fisheries activities within the broader spectrum of the marine sector. As a result, there is increased participation from environmental authorities in the development of tools to implement ocean policies outside the mandate of traditional fisheries arrangements. In addition, the development of oceans policies has driven the reform of environmental and marine legislation to include external assessments of fisheries activities.

Implementation of oceans planning initiatives has driven an expansion of management tools for assessing the marine environment and managing marine resources. Methods common to terrestrial environmental management, such as land use zoning and environmental impact assessment (EIA), have been adapted and used increasingly as tools for integrated planning and assessment of fisheries systems. A recent example of EIA-based methods to assess fisheries is provided by the EPBC initiative (Case 2). This initiative is based on a commitment in Australia's Oceans Policy to assess fisheries by a modified form of EIA, and is implemented by reforms to Commonwealth environmental legislation. The EPBC process uses a series of objectives, criteria and indicators to assess fisheries and improve management plans. The Minister for the Environment makes final decisions on fisheries assessments and grants consent for activities under the Act.

Several other cases provide examples of external agency influence in fisheries management. The NESDRF process (Case 3) has involved a broad range of stakeholders and agencies in developing a national reporting framework for fisheries. In Canada, the development of the MEQ/OBFM process (Case 6) has increased the involvement of oceans and science directorates in fisheries management. Under the MEQ program, fisheries management will be directly tied in with regional strategies that set conservation limits on species and ecosystems. The EPI process (Case 8) is not directly involved in fisheries management decisions, but will be an increasingly important influence in setting targets and management directions. The EPI initiative involves a variety of New Zealand government departments applying indicators, coordinated by the

Ministry for the Environment. Several departments are involved in the collection and analysis of marine information with fisheries specific information collected by the Ministry of Fisheries. The EPI program will be a key influence within fisheries sustainability decisions, with the indicators feeding into and informing decisions that are directly applicable to management.

8. Indicator systems facilitate increased awareness of, and participation in, fisheries management by non-government organisations and civil society.

Modern fisheries management has evolved to consider a variety of stakeholder interests. Consultation mechanisms have generally increased, but full and open participation by the community is lacking in many fisheries regimes. The interest of civil society in marine issues has increased in response to governmental and NGO public awareness programs, the formation of national ocean policy initiatives, major international environmental initiatives (such as Agenda 21 and Johannesburg 2002), and highly public marine crises (such as the Canadian Cod stock collapse). Increased awareness has resulted in increased civil society involvement in the management of fisheries, and recognition that community organisations, on behalf of the resources that are managed for the benefit of society, are legitimate stakeholders in the management process.

Indicator systems not only inform the broader community about activities and issues within the fishery, they can facilitate direct involvement in its decision-making. In the transparent and participatory development of an indicator system stakeholders are involved in the setting of objectives and the selection of indicators. In addition stakeholders can be involved in monitoring programs and contribute feedback into the SIS. When decisions are made on the basis of indicator results, NGO's remain informed and maintain a role in the acceptability and implementation of the findings.

All the cases increase the awareness of fisheries management issues to community and NGO organisations. Indicator systems that focus at the scale of the fishery unit can be more specific over management arrangements in comparison to national initiatives that take a broader view. Several SIS cases have been identified that directly generate increased participation and act as a lever by which NGOs can influence the management of fisheries. The NESDRF (Case 2), EPBC (Case 3), MEQ/OBFM (Case 6) and TLM (Case 7) all increase NGO and civil society awareness and participation in decision-making, primarily through increased consultation. The MSC (Case 10) represents a significant leap forward in NGO participation through its independent and stakeholder based certification scheme. Candidate fisheries are assessed against a series of indicators developed in an open and participatory process. To achieve certification the management authority must meet the requirements set by the indicators and is open to a dispute-resolution process by stakeholders. The MSC initiative is a powerful market based approach has substantially increased and altered the role of the traditional NGO in fisheries management. For fisheries that participate in the program, the MSC initiative can open up new markets and opportunities, and subject them to increased public scrutiny and endorsement.

9. Indicator systems expand the 'fishery equation' and form the basis of management and performance standards.

The development of indicators for marine capture fisheries highlights a variety of measures for environmental, socio-economic, and governance success. These measures expand the base of management concern and explicitly recognise the variety of influences, inputs, outputs, and dynamics within fishery systems. This information is made available via the indicator structure to decision makers and the public.

The expansion from a purely biological, target species based management perspective to an increasingly holistic perspective enables the real linkages in the fishery to be accounted for. The range of issues covered within the cases is diverse, with some cases taking a predominantly target species approach (TLM and NEIS cases), to cases taking into account an array of environmental and socio-economic variables (SoE, EPBC, NESDRF, OBFM, EPI, and MSC cases). It can be observed from the cases that fisheries management and reporting systems are gradually expanding to account for and measure the broader influences that occur within fisheries systems. This expansion is limited by the availability of, and access to, information from research programs and other sectors (ie. economic information).

The translation of these influences and objectives into measurable indicators combined with a means to assess their performance has resulted in SIS emerging as *standards* for benchmarking fishery practice. Standards fulfil a variety of purposes, for example, the ISO 14000 set of standards have been developed as the basis of accrediting environmental management systems (IISD 1996). Standards can be used as the basis of improving fisheries management practice, and can be monitored by decision makers and the public to compare performance and improve outcomes. Several cases use SIS as a formal process of developing standards for management orientation and accreditation. The EPBC (Case 2) and MSC (Case 10) systems follow this approach with a fishery having to meet a series of criteria or achieve a score (based on indicators) to meet the accreditation standard. Other cases such as the NESDRF (Case 3), MEQ/OBFM (Case 6), TLM (Case 7) and EPI (Case 9) indirectly set standards through the recognition and application of their respective indicators in the reporting process and over time, expand and improve the basis of assessment and management within the fishery.

9.5 Conclusion

The synthesis has aimed to identify and assess the roles that indicator systems play as operational tools for moving fisheries towards sustainability outcomes. On the basis of the case studies, it has identified the structures that underlie the functioning of indicator systems as tools to measure, assess and report sustainability, highlighted the practical issues that face indicator system application and implementation at a variety of scales, and strategically assessed the overall performance and outcomes of these systems. This chapter has brought together the observations and results from the case studies. In the conclusion to this thesis, following, the results are considered in a broader context, revisiting the central aim relating to the issues, challenges and outcomes of using indicator systems as tools in fisheries management.

10:Conclusion

Sustainability has been a dominant theme in fisheries management over the past decade, creating an agenda and driving reforms from local fisheries to international negotiations on treaty instruments. As the debate on what constitutes sustainability in the fisheries context has intensified, the use of indicator systems as a tool to operationalise this somewhat nebulous concept has increased in popularity. Sustainability indicator systems offer a means of navigating the complex issues that surround sustainability, a means of reporting and assessing progress towards or away from this goal, and a means of communicating these findings to stakeholders and decision-makers alike. Sustainability indicator systems are diversifying across a multiplicity of uses and jurisdictions, and despite the significant hurdles to be overcome, they are gaining ascent as a means to articulate and implement sustainability in the fisheries sector.

This thesis accepts that there is no absolute truth to the implementation of sustainability. The concept is interpreted and applied in many ways by governments, private sectors, non-government organisations and civil society. Within fisheries, its application raises a number of questions over what the concept means in practice, often leading to rigorous debate over a course of action. As is demonstrated by the case studies, the reporting of sustainability is heterogenous across the fishery context. The cases clearly show several methods to reporting and assessment, with the comparative analysis displaying their relative strengths, weaknesses and common features. The use of indicators facilitates a continual process of identification, monitoring, negotiation and measurement – it is the *process of improvement* that orientates the system toward sustainability, not the quest for an absolute measure or single statistic.

It is this process that lies at the heart of the indicator system. Through the operation of the system sustainability is progressively broken down via a framework into measurable criteria, objectives, and indicators. Incoming information and feedback drives input into the system, while the aggregation, visualisation and communication of the indicator data is essential for decision-making success. Each indicator system (and case study) follows this process to a degree, though significant differences remain in the level of development of different stages and the overall focus. As shown in the case studies, the indicator system is tailored to its particular socio-economic context, its output, and its users. It is the consideration of indicators within a systems context that ensures their effectiveness as fisheries management tools.

As the debate shifted from ‘are indicators useful?’ to ‘how can indicators be used?’ the nature of the research into indicators has followed suit. This thesis is a pioneering attempt to strategically identify and assess the use of indicator systems as tools for achieving sustainability in fisheries by identifying the generic structures and processes that underlie their effectiveness, investigating the issues surrounding their application in diverse jurisdictional contexts, and observing the overall outcomes of using indicator systems as tools in fisheries management.

At first examination, the indicator systems presented via the case studies appear unrelated. This is not surprising, as each system is a result of a complex and unique mix of social, economical, environmental and governance structures. Each indicator system has been built and adapted to its particular context and set of users, and similar to the overarching concept of sustainability, has been adapted and interpreted into a particular set of circumstances. This ensures that the system is *relevant* and maintains an operational focus. However after examination of the sustainability indicator literature and documented practice of indicator systems a number of patterns have emerged and a number of common structures and processes have been identified. The development of the conceptual SIS model draws together the common elements and was successfully fitted to all case studies. The SIS model reflects a systems view, generic structure and the basic processes that drive an indicator system and render it effective. The SIS model represents what each indicator system should aim to achieve to successfully report on or assess sustainable development, and forms the basis of a best practice standard. It is a common lens through which these heterogenous systems can be observed, analysed and ultimately improved in a systematic fashion. It should be noted that no case study has fully achieved the standard set by the model **-** its prime function is a tool by which to identify and assess the underlying core structures and process that influence indicator systems.

The practical application of sustainability indicator systems into fisheries management has revealed a diversity of issues that are critical to success. As identified in the case studies, many indicator systems are in an early phase of development and face ongoing challenges, especially in the generation of information for ecosystem and socio-economic indicators. Examining the application of indicator systems across several jurisdictions has revealed their diversity and versatility and the ongoing transition from a theoretical concept to a practical tool that reports, assesses and implements sustainability.

In identifying the structures and processes that underlie indicator systems, and observing their application across a variety of jurisdictions, this thesis has been able to strategically assess the roles and benefits that are delivered by sustainability indicator systems in fisheries. Indicator systems have clearly demonstrated a number of benefits to fisheries management, and with ongoing development, will provide a sound practical basis for orientating fisheries towards sustainability. These benefits, identified from the results under the analysis framework, include:

- Scientific and policy coordination;
- Informing stakeholder and community organisations;
- Facilitating co-management of fisheries systems;
- Facilitating transparency and accountability in decision-making;
- Contributing to the implementation of ecosystem based management and precautionary approaches;
- A tool for increased external environmental agency involvement in fisheries management;
- Facilitate increased participation in and awareness of fisheries management mechanisms by NGO bodies and the public;
- Forming the basis of management and performance assessment standards;
- Expanding the fisheries ‘equation’ to account for critical broader influences.

The rankings of the case studies on the basis of their performance against the assessment framework highlights the ‘success’ stories of current attempts at measuring and reporting on sustainability issues. It provides a means to assess the current state of play of these systems, identification of the strong and weak points, and a means of comparing their performance over time. To further develop and promote the practice of using sustainability indicator systems, it is essential that these lessons are carried forward and used in new and emerging systems.

This thesis, through the strategic assessment of the use of indicator systems as tools for achieving sustainability, has identified the challenges to successful implementation and future areas of research priority. Feeding the case studies through the SIS model and the common assessment framework has enabled the research to benchmark current practice and identify future challenges and directions. They are listed in priority order:

1. *Improve the information basis of ecosystem and socio-economic indicators*

Ecosystem-based management is increasingly seen as a core component of managing for sustainability. This requires further information on the effects of the ecosystem upon the fishery (for example the physical climate) and the effects of the fishery on the ecosystem (considering predators, competitors, prey, associated species and the broader habitat). Ecosystem-based management has also evolved to consider the socio-economic climate in which fisheries operate. This thesis has highlighted the fact that indicator systems acknowledge that ecosystem-based management is critical, but the level of development of ecosystem and socio-economic indicators is highly variable amongst systems. Indicator systems have stated the general conceptual objectives for ecosystem management, but the development of measurable indicators and performance measures that can be used in the practical management of the fishery remains fragmented and rudimentary with many approaches being limited by the available scientific information. Current and future research is focusing on the information basis for ecosystem and socio-economic effects and generating information that can be used as the basis of indicators and performance measures. An important point to consider for socio-economic measures is the repackaging of existing information into indicators is as necessary as pursuing new research. Often the information for socio-economic indicators exists in other jurisdictions, but needs to be examined and interpreted into an indicator context. This remains a significant challenge for the authority that develops the indicator system.

2. *Developing the outputs from indicator systems – aggregation and visualisation methodologies.*

Most of the research and indicator system development to date has focused on the core structure of indicator systems – the definitions, frameworks, criteria, objectives, indicators and performance measures. This is not surprising as it articulates the primary objective for the indicator system – establishing a comprehensive measuring and reporting system. However as these systems mature, and the information that is a part of them becomes increasingly complex (especially with ongoing research into ecosystem and socio-economic components) information overload becomes a real possibility and any messages from the SIS can be lost in the complexity. Despite the quality of the information that feeds into the system, it essentially becomes useless if that information cannot be used in a decision-making context. The need for aggregation and visualisation methods become critical, with the output from the indicators facilitating a clear, succinct message that can be understood and used by decision makers to implement sustainability. If the indicator system signals a problem, a mechanism should be available to ‘deconstruct’ the issue and go back into the detail of the indicator measures (see the MSC case study). Aggregation and visualisation methods were generally at a developmental level within the cases, and are a critical area for future research. In a climate where increased amounts of complex scientific information are being placed into SIS, the need for clear and simple messages to come out of these systems is essential. This will build support for indicator systems amongst decision makers and the public and increase their overall effectiveness. The aim is to make indicator systems simple – but not lose complexity.

3. *Using indicator systems as the basis of decision rules in management.*

This challenge is directly related to the development of aggregation and visualisation methods. As the quality of information increases and their utility is recognised, indicator systems can expect to be used as the basis of objective decision-making and assessment. This will require the outputs of indicator systems to be linked to specific decision rules and management actions. Since their inception as reporting tools, indicators have been a progressive step for managing for sustainability and a significant improvement from the broad framework outlined in Agenda 21. Their development has improved the information basis for sustainable development, and moved the debate from conceptual ideas to practical measurable outcomes. The next evolutionary step for SIS is a focus upon decision rules as opposed to passive reporting. Several cases identified in the thesis are moving towards this outcome, and will be important examples for moving beyond the current reporting function of indicator systems. Future research on indicator based decision rules will be a priority for increasing their effectiveness and application.

4. *Ongoing research into objectives, indicators, and performance measures.*

Developing an indicator system is an ongoing process of adaptive management. This thesis has shown that the ‘state of the art’ has come a long way in the last ten years, with indicator systems being recognised and used within the fisheries sector across many jurisdictions. Significant effort however still needs to be put into the development of objectives, indicators and performance measures of all dimensions of sustainable development. In addition, ongoing research will improve data sets and find new indicators, and policy priorities will change requiring new objectives. The commitment by authorities to adapt and improve indicator systems will lead to ongoing research applications.

5. *Further refinement and application of the SIS model.*

The SIS model was a key component of this thesis that identified and structured the concept of the sustainability indicator system. The model successfully fit the case studies from a variety of jurisdictions and subjected them to analysis through the assessment framework. Further application to fisheries and non-fisheries indicator systems would validify this approach and progress it as the basis of an SIS standard. Several areas of model improvement could be the focus of future work including different modes of scoring, multicriteria analysis, expert group scoring, and different statistical methods such as geometric averaging. However, the method used in this thesis, a criteria based individual scoring, while simple, is appropriate for identifying the underlying issues and processes surrounding the application of fisheries sustainability indicator systems.

Over the past decade the nature of the debate of sustainability indicators has undergone a significant shift. Initially debate centred on the application and identification of frameworks and indicators and the justification of their use. It was in this period that many of the frameworks and initial indicator measures were classified, debated and refined. Many aspects of the debate still focus on these questions as new sectors investigate the implementation of indicator systems within their sphere of interest. However, among the maturing systems and the state of the art as a whole, a new focus is emerging on the use of indicators in a decision-making context. How indicators are interpreted in the context of objectives and performance measures, how they are communicated via visualisation and aggregation, and how they feed back into management systems are emerging as critical questions. This shift is of great consequence as it recognises that indicator systems focus not only on reporting, but aim to change management practices and ultimately, the behaviour of human beings.

As the focus on fisheries management shifts from a static single species approach to an increasingly holistic perspective that takes into account human and ecological systems, the need for improved information quality assumes great importance. In addition to information quality, information quantity is a critical issue. This is an age where information overload can be a crippling factor, just as a lack of information can cause severe problems. The role of indicator systems is one of highlighting and navigating information complexity, and setting the priorities for research and debate. It allows stakeholders and the public to contribute and become involved, and decision makers to be well informed in managing and regulating the fishery. This thesis has been fortunate to observe sustainability indicator systems in fisheries moving from a phase of conceptual design and consensus building to application as management and decision tools. However, significant challenges remain for their complete implementation as drivers of fisheries sustainability, and it is these challenges that will form the basis of future research. The ingredient for complete success, political will, is needed to halt overfishing, protect habitat, reduce subsidies and support expanded research. It is believed that this will continue to evolve as stakeholders and the public become increasingly informed over fisheries issues, and the Earth's marine living resources will be progressively managed towards sustainable outcomes - away from the trajectory of the current crisis.

References

ABARE (2000). Australian Fisheries Statistics 1999. Canberra, Australian Bureau of Agricultural and Resource Economics**:** 58.

Adler, J., Lugten, G., Kay, R., & Ferris, B. (2001) Compliance with International Fisheries Instruments. In: Fisheries Impacts on North Atlantic Ecosystems: Evaluations and Policy Exploration. Fisheries Centre Research Reports 9 (5). Vancouver. p55-81.

AFMA (1999). Annual Report 1998-1999. Canberra, Australian Fisheries Management Authority.

AFMA (2002). Assessment Report - Southern Bluefin Tuna. Canberra: Australian Fisheries Management Authority.

AFMA (2002b) Draft Assessment Report - Heard and McDonald Islands Fishery. November 2003. Canberra: Australian Fisheries Management Authority.

AFMA (2003a). Australian Fisheries Management Authority Homepage. Cited August 2002. http://www.afma.gov.au

AFMA (2003b) Draft Assessment Report - Torres Strait Prawn Fishery. November 2003. Canberra: Australian Fisheries Management Authority.

AFMA (2003c) Draft Assessment Report -Small Pelagic Fishery. November 2003. Canberra: Australian Fisheries Management Authority.

Agnew, D. (1997). Review: The CCAMLR Ecosystem Monitoring Program. Antarctic Science **9**(3): 235-242.

Agnew, D. (2000). The illegal and unregulated fishery for Toothfish in the Southern Ocean, and the CCAMLR catch documentation scheme. Marine Policy 24(2000): p361-374.

Adler, J., Lugten, G., Kay, R., & Ferris, B. (2001) Compliance with International Fisheries Instruments. In: Fisheries Impacts on North Atlantic Ecosystems: Evaluations and Policy Exploration. Fisheries Centre Research Reports 9 (5). Vancouver. p55-81.

Alverston, D. L., Freeberg, M.H., Murawski, S.A., and Pope, J.G. (1994). FAO Fisheries Technical Paper. A global assessment of fisheries bycatch and discards. Rome, FAO**:** 233p.

Anderson, D. W., Gress, F., Mais, and Kelly, P.R. (1980). Brown pelicans as anchovy stock indicators and their relationships to commercial fishing. CalCOFI Report **21**: p54-61.

SCOPE (1995). Report on the Workshop on Indicators of Sustainable Development for Decision Making. Ghent, Belgium, Scientific Committee on Problems in the Environment / UNEP / CSD**:** 128p.

Anon (2002). Leadership at Johannesburg. Nature 418: 2p.

ANZECC (2000). Core Environmental Indicators for Reporting in the State of the Environment. Canberra, Australian and New Zealand Environment and Conservation Council: 92p.

Arbour, J., Cobb, D. Courtenay, S., Gregory, Levings, C, Munro, J., Perry, I and Vandermeulen, H. (2001). Proceedings of the National Workshop on Objectives and Indicators for Ecosystem Based Management. Sidney, Fisheries and Oceans Canada.126p.

ASOC, Antarctic and Southern Ocean Coalition (2001). ASOC Submission on the Moody Marine assessment of the suitability of the South Georgia and South Sandwich Islands Patagonian Toothfish Fishery for certification by the Marine Stewardship Council. Washington, ASOC**:** 18p.

Auditor General of Canada (1997). 1997 Report of the Auditor General, Chapter 14: Sustainable Fisheries Framework: Atlantic Groundfish. Ottawa, Office of the Auditor General, Canada. 14-18p.

Auditor General Canada (1999). Auditor General Report: Chapter 4, Fisheries and Oceans, Managing Atlantic Shellfish in a Sustainable Manner. Ottawa, Office of the Auditor General**:** 35p.

Australian State of the Environment Committee. (1996). State of the Environment Report 1996. Canberra, CSIRO Publishing for Department of Environment and Heritage.

Australian State of the Environment Committee (2001). Australia State of the Environment 2001. Canberra, CSIRO Publishing for Department of Environment and Heritage.

Baker, D. (1996). Your work is of value, prove it or perish. 2nd World Fisheries Congress: Developing and Sustaining World Fisheries Resources - The State of the Science and Management, Brisbane, CSIRO Publishing.

Bakkes, J., van den Born, J., Helder, J., Swart, R., Hope, C., & Parker, J.D. (1994). Environment Assessment and Technical Reports: An Overview of Environmental Indicators: State of the art and perspectives. Nairobi, United Nations Environment Program (UNEP).

Beddington, J. R., and Cooke, J. (1983). The potential yield of fish stocks. FAO Fisheries Technical Paper. Rome, Food and Agricultural Organisation of the UN**:** 47p.

Bell, S and Morse, S (1999). Sustainability Indicators: Measuring the Immeasurable. London, Earthscan Publications.223p.

Bell, S and Morse, S. (2001). Breaking through the glass ceiling: who really cares about sustainability indicators? Local Environment 6(3): p291-309.

Berkes et al, F., Mahon, R., McConney, P., Pollnac, R., & Pomeroy, R. (2001). Managing Small Scale Fisheries: Alternative Directions and Methods. Ottawa, International Development Research Center.307p.

Birnie, P., & Boyle, A. (1995). Basic Documents on International Law and the Environment. Oxford, Oxford University Press.

Bonzon, A. (2000). Development of economic and social indicators for the management of Mediterranean fisheries. Marine Freshwater Research 51: p493-500.

Bossel, H. (1999). Indicators for Sustainable Development: Theory, Method, Applications. Winnipeg, International Institute for Sustainable Development**:** 124p.

Botsford, L. W. (1997). The management of fisheries and marine ecosystems. Science **275**(5325): 7.

Bowen, B. K. (1996). What are the roles of Science, Economics, Sociology and Politics in Fisheries Management? 2nd World Fisheries Congress: Developing and Sustaining World Fisheries Resources - The State of the Science and Management, Brisbane.p169-77.

Buckley, R. (1991). Policy Tools for Sustainable Development. Search **22**(8): p281-284.

Buckworth, R. (1998). World Fisheries in Crisis. Reinventing Fisheries Management. T. J. Pitcher, Paul, J.B., and Pauly, D. London., Kluwer Academic Publishers.**:** p3-17.

Butterworth, D. S., Punt, A.E., and Basson, M. (1992). A simple approach for calculating the potential yield from biomass survey results. Selected Scientific Papers 1991. Hobart, SC-CCAMLR**:** p207-15.

BRS, Bureau of Rural Sciences Australia, (2000). Fishery Status Reports 1999: Resource Assessments of Australian Commonwealth Fisheries. Canberra., Bureau of Rural Sciences Australia.**:** 250p.

Caddy, J. F. (1998). A Short Review of precautionary reference points and some proposals for their use in data poor situations. FAO Fisheries Technical Paper. Rome., FAO**:** 30p.

Caddy, J. F. (1999a). Deciding on precautionary measures for a stock based on a suite of Limit Reference Points (LRPs) as a basis for a multi-LRP harvest law. NAFO Science Count Studies **32**: 55-68.

Caddy, J. F. (1999b). Fisheries Management in the twenty-first century: will new paradigms apply? Reviews in Fish Biology and Fisheries. **9**(1-43): 43p.

Caird, J., Huxley, T.H., Lefevre, G.S. (1866). Report of the Commissioners appointed to inquire into the Sea Fisheries of the United Kingdom: Volume 1. London, Queen Victoria and the UK Parliament.

CCAMLR (1980). Convention of the Conservation of Antarctic Marine Living Resources. Hobart, Australia.

CCAMLR (2001a). CCAMLR Ecosystem Monitoring Program: Standard Methods. Hobart, CCAMLR**:** 268p.

CCAMLR (2001b). CCAMLR's Management of the Antarctic. Hobart, Commission for the Conservation of Antarctic Marine Living Resources. Cited from:http://www.ccamlr.org/publications

CCAMLR (2002a). CCAMLR Homepage. Cited: http://www.ccamlr.org/publications

CCAMLR (2002b). Report of the Twenty-First Meeting of the Commission. Hobart, CCAMLR.

CGSDI, Consulting Group on Sustainable Development Indicators (2002). The Dashboard Model, CGSDI and IISD. 2003. http://iisd.org/cgsdi/intro_dashbord.htm

Charles, A.T. (1994) Towards Sustainability: the fishery experience. Ecological Economics. 11 (1994). p 201-211.

Charles, A.T. (1995) Sustainability Assessment and Bio-Socio-Economic Analysis: Tools for Integrated Coastal Development. In: Philippine Coastal Resources Under Stress, Juinio-Menez & Newkirk (Editors), Coastal Resources Research Network, Halifax, Canada and Marine Science Institute, Philippines. p 115-125.

Charles, A.T. (1997). The Path to Sustainable Fisheries. In: 'Peace in the Oceans : Ocean Governance and the Agenda for Peace. The Proceedings of Pacem in Maribus XXIII.' Mann-Borgese, E. (Editor). Costa Rica, Intergovernmental Oceanographic Commission**:** p201-213.

Charles (1997) Sustainability Indicators: An Annotated Bibliography with emphasis on Fishery Systems, Coastal Zones and Watersheds. Strategy for International Fisheries Research, Ottawa, Canada. 86p.

Charles, A.T. (1998a). Fisheries in Transition. Ocean Yearbook 13. C. Mann-Borgese, A., McConnell, M & Morgan, J.R. (Editors) . University of Chicago Pres, Chicago. p 15-37.

Charles, A.T. (1998b) Living with uncertainty in fisheries: analytical methods, management priorities, and the Canadian groundfishery experience. Fisheries Research: 37(1998). p37-50.

Charles A.T. (2002) The precautionary approach and 'burden of proof' challenges in fishery management. Bulletin of Marine Science: 70(2). p683-694.

Charles, A.T; Boyd, H., Lavers, A., & Benjamin, C. (2002) The Nova Scotia GPI Fisheries and Marine Environment Accounts: A Preliminary Set of Ecological, Socio-economic and Institutional Indicators for Nova Scotia's Fisheries and Marine Environment. GPI Atlantic, Tantallon, Canada. 62p.

Chesson, J. (1998). A framework for assessing fisheries with respect to ecologically sustainable development. Canberra, Bureau of Rural Sciences**:** 60p.

Chesson, J. (2000). A General Framework for Generating Indicators of Sustainable Development. Bureau of Rural Sciences, BRS**:** 10p.

Chesson, J., Clayton, H., and Whitworth, B. (1999). Evaluation of fisheries management systems with respect to sustainable development. ICES Journal of Marine Science **56**: 980-984p

Chesson, J., Whitworth, B, and Smith, T. (2000). Reporting on Ecologically Sustainable Development: The Reporting framework of the Standing Committee on Fisheries and Aquaculture in relation to national and international experience. Canberra, Bureau of Rural Sciences**:** 100p.

Christensen, V. (2000). Indicators for marine ecosystems affected by fisheries. Marine and Freshwater Research **51**: 447-50p.

CIESIN, Centre for International Earth Science Information Network (2003). Environmental Treaties and Resource Indicators (ENTRI) website. Palisades, NY: CIESIN. Cited from http://sedac.ciesin.org/entri/

Clarke, T. (2002).Wanted: Scientists for Sustainability. Nature 418. p812-815.

Cobb, D, Eddy, S., & Banias, O. (2001). Canadian Manuscript Report of Fisheries and Aquatic Sciences: Examining the Health of the Hudson Bay Ecosystem, Proceedings of the Western Hudson Bay Workshop. Winnipeg, DFO Central and Arctic Region.**:** 38p.

Colman, R (2002) GPI Atlantic statement on The NRTEE's Environment and Sustainable Development Indicators Initiative. Accessed from: http://www.gpiatlantic.org/releases/pr_esdi_stmt.shtml

Committee on Ecosystem Management for Sustainable Fisheries (1999). Sustaining Marine Fisheries. Washington DC, National Research Council**:** 130p.

Commonwealth of Australia (1989). New Directions for Commonwealth Fisheries Management in the 1990's: A Government Policy Statement. Canberra, Commonwealth of Australia, AGPS.

Commonwealth of Australia (1991a). Ecologically Sustainable Development Working Group Chairs: Intersectoral Issues Report. Canberra, Commonwealth of Australia**:** 248p.

Commonwealth of Australia (1991b). Ecologically Sustainable Development Working Groups: Final Report Fisheries. Canberra, Ecologically Sustainable Development Working Group**:** 202p.

Commonwealth of Australia (1991c). Fisheries Management Act 1991.

Commonwealth of Australia (1992). National Strategy for Ecologically Sustainable Development. Canberra, Commonwealth of Australia**:** 128p.

Commonwealth of Australia (1998a). Australia's Ocean Policy - Specific Sectoral Measures. Canberra, Commonwealth of Australia**:** 48p.

Commonwealth of Australia (1998b). Australia's Oceans Policy. Canberra, Commonwealth Government**:** 48.

Commonwealth of Australia (2002a). Environment Protection and Biodiversity Conservation Act, Environment Australia. 2002.

Commonwealth of Australia (2002b). Guidelines for the Ecologically Sustainable Management of Fisheries. Canberra, Commonwealth of Australia**:** 15p.

Communications Directorate. (1997). Toward Canada's Oceans Strategy. Ottawa, Public Works ad Government Services Canada.

Connor, R. (1999). Trends in Fishing Capacity and Aggregation of Fishing Rights in New Zealand under ITQs. FishRights 99, Fremantle, Western Australia,. FRDC. 14p.

Constable, A. J. (2002). CCAMLR ecosystem monitoring and management: future work. CCAMLR Science 9: 233-523.

Constable, A. J., de la Mare, W.K., Agnew, D.J., Everson, I., 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: p778-791.

Constanza, R. (1998). Principles for sustainable governance of the oceans. Science 281(5374): p198-202.

Council of Australian Governments (1992). Intergovernmental Agreement on the Environment. Canberra, COAG.

Counsell, S & Loraas, K. (2002) Trading in Credibility: The Myth and Reality of the Forest Stewardship Council. The Rainforest Foundation, London. 156p.

Crawford, R. J., and Shelton, P. (1981). Population trends for some Southern African seabirds related to fish availability. Proceedings of a Symposium on Birds of the Sea and Shore. J. Cooper. Cape Town, African Seabird Group.**:** 1.

Dahl, A. L. (1995). Towards Indicators of Sustainability. SCOPE Scientific Workshop on Indicators of Sustainable Development., Belgium.230p.

Dahl, A. L. (2000). Using indicators to measure sustainability: recent methodological and conceptual developments. Marine Freshwater Research **51**: 427-33.

Daly, G, & Erlich, P. (1995). Socio-economic equity: A Critical element in Sustainability. Ambio **24**(1).

De Fontaubert, C. (1998). Managing Marine Resources Under International Law: Challenges and Opportunities. Seaviews Conference: Marine Ecosystem management: obligations and opportunities. Wellington, New Zealand., Environment and Conservation Organisations of New Zealand.

Dept of Fisheries Western Australia. (2002). National Fisheries ESD Website, Department of Fisheries Western Australia and FRDC. Cited 2002/3. http://www.fisheries-esd.com.au.

Des Clers, S. & Nauen, C. (2002). New Concepts and Indicators in Fisheries and Aquaculture. Brussels, ACP-EU Fisheries Research Initiative. 71pp.

Commissioner for ESD. (2001). Report of the Commissioner for Environment and Sustainable Development to the House of Commons. Ottawa, Office of the Auditor General of Canada.**:** 48p.

Devine, F. (1995). Qualitative Methods. Theory and methods in Political Science. D. S. Marsh, G. New York, St Martins Press.

DFO, Department of Fisheries and Oceans Canada (1997a). The Role of the Federal Government in the Oceans Sector. Ottawa, Department of Fisheries and Oceans**:** 38p.

DFO, Department of Fisheries and Oceans Canada (1997b). The Role of the Provincial and Territorial Government in the Oceans Sector. Ottawa, Department of Fisheries and Oceans.

DFO, Department of Fisheries and Oceans Canada (1999a). Framework and Guidelines for Implementing the Co-management Approach. Volume 1: Context, Concept and Principles. Ottawa, DFO**:** 20p.

DFO, Department of Fisheries and Oceans Canada (1999b). Framework and Guidelines for Implementing the Co-Management Approach. Volume 2: Integrated Fisheries Management Plans. Ottawa, DFO.

DFO, Department of Fisheries & Oceans. (1999c). Framework and Guidelines for Implementing the Co-Management Approach. Volume 3: Joint Project Agreements. Ottawa, Department of Fisheries and Oceans. 22p.

DFO, Department of Fisheries and Oceans Canada (2000). Guidelines for Objective Based Fisheries Management. Draft 3. Ottawa, DFO**:** 20p.

DFO, Department of Fisheries and Oceans Canada (2001). Haddock on the Eastern Scotian Shelf (Div 4TVW). DFO Science Stock Status Report., Department of Fisheries and Oceans.

DFO, Department of Fisheries and Oceans Canada. (2002). Integrated Fisheries Management Planning. DFO. Cited from: http://www.pac.dfo-mpo.gc.ca/ops/fm/IFMP/default.htm#HISTORY

Dhakal, S. and Hidefumi, I. (2003). Policy-based Indicator Systems: emerging debates and lessons. Local Environment **8**(1): p113-119.

Dobell, R. & Charles, A.T. (2002). Canada's Pacific and Atlantic Fisheries: Governance and Policy Trends. Australian and Canadian Oceans Research Network Conference, Canberra, Australia.

Dovers, D. R. (1993). Contradictions in Sustainability. Environmental Conservation **20**(3): 217-222.

Dovers, S. (1990). Sustainability in Context: An Australian Perspective. Environmental Management **14**(3): 297-305.

Dovers, S. (1997). Sustainability: Demands on Policy. Journal of Public Policy **16**: 303-318p.

Dovers, S. (2001). Informing Institutions and Policies. Towards Sustainability: systems for monitoring sustainable development. J. Higgis, & Venning, J. Sydney, University of NSW Press.196-220p.

Dovers, S. & Handmer, J. (1995). Ignorance, the Precautionary Principle and Sustainability. Ambio 24(2): p92-97.

DM Consultants. (2001). Phase 1 Background Document: Renewable Resources, Sustainable Development Indicators. Submitted to the NRTEE ESDI Initiative. Ottawa, NRTEE**:** 38p.

Drynan, M. (2001). Reporting on Ecologically Sustainable Development for Australian Fisheries. Waves: The Marine and Coastal Community Network. **7**(4): 6p.

Ecosystems Advisory Panel (1999). Ecosystem Based Fishery Management, US Department of Commerce, National Marine Fisheries Service**:** 42p.

Edwards, D., and Glavin, T., (1999). Set Adrift: The Plight of British Columbia's Fishing Communities. Vancouver, David Suzuki Foundation.**:** 32p.

Emerson, W. (1995).Hitting the high seas. OECD Observer August-September (195): 4p.

Environment Australia (1996). Australia's 1996 National Report to the UN Commission on Sustainable Development - Oceans Chapter 17 of Agenda 21., Environment Australia.

Environment Australia (2002). Fisheries and the Environment - Sustainable Fisheries Section Homepage, Environment Australia. Cited 2002. http://www.ea.gov.au/coasts/fisheries/index.htm

Environment Canada (1995). A Guide to Green Government. Ottawa, Canadian Government. 25p.

Environment Canada (1996). State of the Environment Report. Ottawa, Environment Canada.165pp

Environment Canada (1998). National Environmental Indicator Series: Sustaining Marine Resources: Pacific Herring Fish Stocks. Ottawa, Indicators and Assessment Office, Environment Canada.5p

Environment Canada (2002). State of the Environment Infobase: National Environmental Indicator Series. Indicators and Assessment Office. Cited from: http://www.ec.gc.ca/soer-ree/English/about.cfm.

Espejo, R. & Stewart, N. (1998). Systematic Reflections on Environmental Sustainability. Systems Research and Behavioral Science 15(6): p483-494.

Essington, T. E. (2001). The precautionary approach in fisheries management: the devil is in the details. Trends in Ecology and Evolution 16(3): p121-123.

Everson, I. (2002). Consideration of major issues in ecosystem monitoring and management. CCAMLR Science 9: 213-232.

Fairlie, S., Hagler, M., and O'Riordian, B. (1995). The politics of overfishing. The Ecologist 25(2-3): p28.

Fanning, P., Mohn, R., Hallday, R. (2002). Application of TL method within Precautionary Approach, Objectives-Based Fisheries Management, Intensive Fisheries Evaluations and considering Fisheries Resource Conservation Plans. Dartmouth, DFO Maritimes.18p.

FAO (1989) Sustainable development and natural resources management. FAO Conference Twenty-fifth Session, C89/2-supp.2. Rome, Food and Agriculture Organization of the United Nations.

FAO (1995) FAO International Code of Conduct for Responsible Fisheries. Rome, Food and Agriculture Organisation on the United Nations: 32p.

FAO (1998). State of World Fisheries and Aquaculture (SOFIA). Rome, Food and Agriculture Organisation of the United Nations. 90p.

FAO (1999a). FAO Technical Guidelines for Responsible Fisheries No.8: Indicators for Sustainable Development of Marine Capture Fisheries. Rome, Food and Agriculture Organisation of the United Nations: 62p.

FAO (1999b). Information on Fisheries Management in New Zealand, Food and Agriculture Organisation. Cited 2002. http://www.fao.org/fi/fcp/en/NZL/body.htm

FAO (1999c). RAPFISH, A Rapid Appraisal Technique for Fisheries, and its Application to the Code of Conduct for Sustainable Fisheries. FAO Fisheries Circular 947. FIRM/C947. Rome, Food and Agriculture Organisation of the United Nations: 47.

FAO (2000). State of World Fisheries and Aquaculture (SOFIA). Rome, Food and Agriculture Organisation of the United Nations. 87p.

FAO (2002). State of World Fisheries and Aquaculture (SOFIA). Rome, Food and Agriculture Organisation of the United Nations. 102p.

FAO (2003a) Criteria and Indicators for Sustainable Forest Management. Report #16588. Cited from http:// www.fao.org/forestry/site/16588/en. Food and Agriculture Organisation of the United Nations. Rome.

FAO (2003b) International Conference on the Contribution of Criteria and Indicators for Sustainable Forest Management: The Way Forward: Volume 1.3. International Conference on the Contribution of Criteria and Indicators for Sustainable Forest Management, 7 February 2003, Guatemala. Food and Agriculture Organisation of the United Nations.132p.

FAO (2003c) State of the Worlds Forests 1997. Food and Agriculture Organisation of the United Nations. Cited from: http://www.fao.org/docrep/w4345e/w4345e00.htm#Contents

FAO (2003d) Forestry Management Working Paper: Sustainable Forest Management and the Ecosystem Approach: Two Concepts One Goal. Working Paper FM 25. Food and Agriculture Organisation of the United Nations. Rome.

Feeny, D., Hanna, S., and McEvoy, A.F. (1996). Questioning the assumptions of the "tragedy of the commons" model of fisheries. Land Economics **72**(2): p187-206.

Fisher, D. (1996). Legal Regimes for Fishery Resource Management. 2nd World Fisheries Congress: Developing and Sustaining World Fisheries Resources - The State of the Science and Management, Brisbane, CSIRO Publishing p312-218.

Fisheries Centre (1998) Distant Water Fleets: An Ecological, Economic and Social Assessment. Fisheries Centre Research Reports 1998 6 (6). 113p.

Fletcher, W., Chesson, J., Sainsbury, K., Hundloe, T., and Fisher, M. (2001). Development of an ESD reporting framework for fisheries: progress, problems and benefits. Outlook Conference, ABARE.

Fletcher, W., Chesson, J., Fisher M., Sainsbury, K.J., Hundloe, T., Smith, A. & Whitworth, B (2002). National ESD Reporting Framework for Australian Fisheries: The 'How To' Guide for Wild Capture Fisheries. Canberra.120p.

Fogg, G. (1992). A History of Antarctic Science. Cambridge, Cambridge University Press. 125p

Forest Certification Resource Centre (2003) Forest Certification Resource Centre Homepage. Cited from http://www.certifiedwood.org/. Updated: Dec 2003.

Forest Stewardship Council (2003) Forestry Stewardship Council International Homepage. Cited from http://www.fscoax.org/

Forest Stewardship Council (2003) FSC Principles and Criteria. Document 1.2: 2000. Forestry Stewardship Council International. Cited from http://www.fscoax.org/principle.htm

Fowler, C. (1999). Management of multi-species fisheries: from overfishing to sustainability. ICES Journal of Marine Science **56**: p927-932.

Fowler, P (1998). Learning from the Marine Stewardship Council: A Business-NGO Partnership for Sustainable Marine Fisheries. Greener Management International Winter 1998: p77-90.

France, M. (1996). Industry Must be part of the Fisheries Management problem. 2nd World Fisheries Congress: Developing and Sustaining World Fisheries Resources - The State of the Science and Management, Brisbane, CSIRO Publishing.

Frazier, J. G. (1997). Sustainable Development: modern elixir or sack dress? Environmental Conservation **24**(2): p182-193.

FRDC, Fisheries Research and Development Corporation. (2002) Fisheries ESD Website: Catching Sustainability. FRDC, Fisheries Western Australia. Cited 2002. http://www.frdc.com.au

FRCC (2002). Fisheries Resource Conservation Council Homepage.http://www.frcc.gov.ca

Friedheim, R. L. (1999). Ocean Governance at the millennium: where we have been - where we should go. Ocean and Coastal Management 42: p747-765.

Friend, A., & Rapport, D. (1979). Towards a comprehensive framework for Environment Statistics: A Stress-Response Approach. Ottawa, Statistics Canada.

Garbin, N. (1999). Effectiveness and Efficiency of the Whaling Regime. Honours Thesis: Institute of Antarctic and Southern Ocean Studies. Hobart, University of Tasmania. 108p.

Garcia, S. (2000). The FAO definition of sustainable development and the Code of Conduct for Responsible Fisheries: an analysis of the related principles, criteria and indicators. Marine and Freshwater Research **51**: p535-41.

Garcia, S., & Moreno, I. (2001). Global overview of marine fisheries. Reykjavik Conference on Responsible Fisheries in the Marine Ecosystem, Reykjavik, Iceland, 1-4 October 2001.

Garcia, S. (1994). FAO Fisheries Circular No. 871 - The Precautionary Approach to Fisheries with Reference to Straddling Fish Stocks and Highly Migratory Fish Stocks. Rome, Food and Agriculture Organisation of the United Nations.**:** 76p.

Garcia, S, and Grainger, R. (1996). Fisheries Management and Sustainability: A New Perspective of an old Problem? World Fisheries Congress, Brisbane, Australia, CSIRO Publishing. p631-654.

Garcia, S. M., and Hayashi, M. (2000). Division of the oceans and ecosystem management: A contrastive spatial evolution of marine fisheries governance. Ocean and Costal Management 43: p445-474.

Garcia, S. M., and Staples, D. (2000). Sustainability Indicators in Marine Capture Fisheries: introduction to the special issue. Marine and Freshwater Research 51: p381-4.

Garcia, S. M., and Staples, D.J. (2000). Sustainability reference systems and indicators for responsible marine capture fisheries: a review of concepts and elements for a set of guidelines. Marine and Freshwater Research. 51: p385-426.

Garcia, S. M., Staples, D.J. and Chesson, J. (2000). The FAO guidelines for the development and use of indicators for sustainable development of marine capture fisheries and an Australian example of their application. Ocean and Coastal Management 43: p537-556.

Gardiner, R. (2002). Earth Summit 2002 Briefing Paper: Earth Summit Explained. Johannesburg, UNCED Stakeholder Forum**:** 10p.

Gilbert, D, Annla, J, and Johnston, K. (2000). Technical background to fish stock indicators for state-of-environment reporting in New Zealand. Marine and Freshwater Research 51: p451-64.

Gill, S. (1999). Working towards an economically and environmentally sustainable industry. Sydney, Master Fish Merchants Association**:** 4p.

Glavin, T. (1998). Last Call: A report of the Pacific Salmon Forests Project. Vancouver, David Suzuki Foundation**:** 32p.

Goodlund, R., Daly, H, and Serafy, S. (1993). The Urgent Need for Rapid Transition to Global Environmental Sustainability. Environmental Conservation 20(4): p297-309.

Government of Canada (1991). The State of Canada's Environment. Ottawa, Environment Canada. Cited from http://www.ec.gc.ca/soer-ree/English/about.cfm

Government of Canada (1996). The Oceans Act 1996

Government of Canada (2001a). A Canadian Perspective on the Precautionary Approach / Principle: Proposed Guiding Principle. Ottawa, Government of Canada**:** 16p.

Government of Canada (2001b). The Management of Fisheries on Canada's Atlantic Coast: A Discussion Document on Policy Direction and Principles. Ottawa, Atlantic Fisheries Policy Review.

Government of Canada (2001c). Monograph No16: Information for Decision Making in Sustainable Development. Ottawa, Natural Resources Canada. 36p.

Government of Canada (2002a). Sustainable Development: A Canadian Perspective. Ottawa, Government of Canada**:** 129p.

Government of Canada (2002b). Canada's Oceans Strategy: Our Oceans, Our Future. Ottawa, Government of Canada**:** 39p.

Government of Canada (2002c). Canada's Ocean Strategy: Operational Guidelines for Integrated Management of Estuarine, Coastal and Marine Environments in Canada. Ottawa, Government of Canada.

Government of New Zealand (1996). Fisheries Management Act. Wellington, Government of New Zealand.

Government of New Zealand (2002). The Governments approach to Sustainable Development. Wellington, New Zealand Government**:** 53.

Green, J. (2001). Australian maritime boundaries: the Australian Antarctic Territory. Marine Policy 25: 1-11.

Grotius, H. (1604). Mare liberium [translated in 1916: The Freedom of the Seas]. New York, Oxford University Press.

GTA Consultants (1998). Review Directorate: Review of Integrated Fisheries Management Plans. Ottawa, Fisheries and Oceans Canada.

Gulland, J. A. (1983). Fish Stock Assessment. London, Wiley.208p.

Gulland, J. (1971.). The fish resources of the ocean. Oxford, Fishing News Books (Intl.).255p.

Haggan, N. (1998). Reinventing the tree: reflections on the organic growth and creative pruning of fisheries management structures. Reinventing Fisheries Management. T. J. Pitcher, Hart, J.B., & Pauly, D. London, Kluwer Academic Publishers**:** p20-29.

Hall, C. (1998). Institutional solutions for governing the global commons: design factors. Journal of Environment and Development 7(2): 20.

Halliday, R. G., Fanning, L.P and Mohn, R.K. (2001). Use of the Traffic Light Method in Fishery Management Planning. Dartmouth, Canada., Bedford Institute of Oceanography, Department of Fisheries and Oceans.**:** 40p.

Hanna, E. (2002). NRTEE ESDI: Final Report: Renewable Marine and Forest Resources Cluster Report. Ottawa, NRTEE**:** 42.

Hannesson, R. (1995). Fishing on the High Seas: Cooperation or competition? Marine Policy 19(5): 5.

Hanson, A. (2003). Measuring Progress through sustainable development. Ocean and Coastal Management. 46: p381-390.

Harden-Jones, F. R. (1994). Fisheries Ecologically Sustainable Development: Terms and Concepts. Hobart, Institute of Antarctic and Southern Ocean Studies. 49p

Hardi, P & Pinter, L. (1995). Models and Methods of Measuring Sustainable Development Performance. Winnipeg, IISD. 15p

Hardi, P. & Zdan, T. (1997). Assessing Sustainable Development: Principles in Practice. Winnipeg, International Institute for Sustainable Development.**:** 175p.

Hardi, P., Barg, S., & Hodge, P. (1997). Measuring Sustainable Development. Winnipeg, IISD**:** 48p.

Harding, L. (1992). Measures of Marine Environmental Quality. Marine Pollution Bulletin 25: 23-27.

Harris, L. (1995). The East Coast Fisheries. Resource and Environmental Management in Canada. B. Mitchell. Toronto, Oxford University Press.

Haward, M. (1989). The Australian Offshore Constitutional Settlement. Marine Policy 13: p334-338.

Haward, M and Wilson, M. (1999). Co-Management and Rights Based Fishers. Fish Rights '99, Fremantle.12p.

Haward, M., Bache, S, Tsamenyi, M., & Rose, G. (2001). Fisheries. Integrated Oceans Management: Issues in Implementing Australia's Oceans Policy. M. Haward (Ed). Hobart, Antarctic CRC.

Haward, M., Dobell, R., Charles, T., Foster, L., & Potts, T . (2002). Fisheries and Oceans Governance in Australia and Canada: From Sectoral Management to Integration? Dallhousie Law Journal, In Press.

Hardin, G (1968). The Tragedy of the Commons. Science, 162(1968):p1243-1248.

Hawley, T. (1989). Managing the Oceans: Large Marine Ecosystems. Technology Review 92(2): 18.

Herr, R., & Haward, M. (2001). Australia's Oceans Policy: Policy and Process. In: Integrated Oceans Management: Issues in Implementing Australia's Oceans Policy. M. Haward. Hobart, Antarctic CRC. Research Report 26.

Herriman, M., Tsemanyi, M., & Bateman, S. (1997). Australia's Ocean Policy Background Paper 2. Review of International Agreements, Conventions, Obligations and Other Instruments Influencing the Use and Management of Australia's Marine Environment. A Report Commissioned by Environment Australia. Wollongong, University of Woolongong.144p.

Hewitt, R. P. (2000). The Fishery on Antarctic Krill: Defining an Ecosystem Approach to Management. Reviews in Fishery Science 8(3): p235-298.

Higgins, J. (2001). Environmental Models. In: Towards Sustainability: Emerging Systems for Sustainable Development. J. H. Venning, J. Sydney, UNSW Press. 48-71p.

Hill, M. (1997). The Policy Process in the Modern State., Hemel Hempstead: Prentice Hall.

Hodge, R. (1995). Assessing Progress Towards Sustainability. In: The Role of ENGO's in North America, Sante Fe, The North American Institute.

Hogwood, B, & Gunn, L. (1984). Policy Analysis for the Real World. Oxford, Oxford University Press. 165p.

Hundloe, T. (2000). Economic Performance Indicators for fisheries. Marine Freshwater Research 51: p485-91.

Hyatt, D. E. (1999). Environmental Indices: Old Problems, New Challenges. An Overview of the Role of Environmental Indices in Science and Policy. In: Environmental Indices Systems Analysis Approach. Hyatt, D, & Lenz, R. Oxford, EOLOSS Publishers Co. Ltd. 264p.

IISD, International Institute for Sustainable Development. (1996). Global Green Standards: ISO 14000 and Sustainable Development. Winnipeg, IISD**:** 100p.

IISD, International Institute for Sustainable Development (1999). Sustainable Development Timeline. IISD.

IISD (2001). International Institute for Sustainable Development Home Page. IISD. http://www.iisd.org.ca

Institute, New Zealand Antarctic. (2001). Ross Sea Region 2001: A State of the Environment Report for the Ross Sea Region of Antarctica. Christchurch, New Zealand Antarctic Institute.

International Oceanographic Commission (2001). Toward the World Summit on Sustainable Development. Reports of the Working Groups. The Global Conference on Oceans and Coasts 2001., Paris, IOC, UNESCO.

ISOFISH (1999). The Chilean Fishing Industry: It s Involvement in and Connections to the Illegal, Unreported and Unregulated Exploitation of Patagonian toothfish in the Southern Ocean. Hobart, International Southern Oceans Longline Fisheries Information Clearing House**:** 95p.

IUCN and WWF. (1998). Creating a Sea Change: The WWF / IUCN Marine Policy. London, UK., World Wildlife Fund and International Union for the Conservation of Nature.**:** 64p.

IUCN (1980). World Conservation Strategy. Living Resource Conservation for Sustainable Development. Gland, Switzerland, International Union for the Conservation of Nature & United Nation Environment Program, FAO/UNESCO: 44p.

Iversen, E. (1996). Living Marine Resources: Their Utilisation and Management. New York, Chapman and Hall.185p.

Jessinghaus, J. (1999). A European System of Environmental Pressure Indices: First Volume of the Environmental Pressure Indices Handbook. Theoretical and Political background. European Commission Joint Research Centre. 161p.

Jessinghaus, J. (1999). Indicators for Decision Making. Ispra, European Commission.45p.

Jessinghaus, J. (2003). Dashboard Homepage, EU Joint Research Centre. Cited 2003. http://esl.jrc.it/dc/index.htm

Jones, G., Forbes, J and Hollier, G. (1990). Collins Reference Dictionary: Environmental Science. Glasgow, Collins Sons & Co Ltd: 89p.

Juda, L. (1999). Considerations in Developing a Functional Approach to the Governance of Large Marine Ecosystems. Ocean Development and International Law. 30: 89-125.

Juda, L. (2001). The United Nations Fish Stocks Agreement. Yearbook of International Cooperation on Environment and Development 2001/2002. Stokke, O., & Thommessen,.B. Fridtjof Nansen Institute, Norway. 164p.

Kay, D.& Hughes, N. (2000). Sustainable Fisheries. National Outlook Conference, Canberra, ABARE.5p.

Kaye, S. (2001). International Fisheries Management. The Hague, Kluwer Law International.280p.

Kaye, S., Rothwell, D., and Haward, M. (2000). Ecosystem Management in the Southern Ocean. Integrated Oceans Management: Issues in Implementing Australia's Ocean Policy. ACORN Conference., Vancouver, Canada., Antarctic CRC.41-55p.

Kellermann, A., and North, A. (1994). The contribution of the BIOMASS Program to Antarctic Fish biology. Southern Ocean Ecology: the Biomass perspective. S. Z. El-Sayed. Cambridge, Cambridge University Press.**:** 191-208.

Kesteven, G. (1997). MSY Revisited. Marine Policy 21(1): p73-82.

King, M. (1995). Fisheries Biology, Assessment and Management. Oxford, Fishing News Books.

Knox, G. (1994). The Biology of the Southern Ocean. Cambridge, Cambridge University Press.425p.

Kock, K.H. (1992). Antarctic Fish and Fisheries. Cambridge, Cambridge University Press. 225p

Kock, K.H. (2000). Understanding CCAMLRs approach to management. Hobart, CCAMLR**:** 57p
.

Kock, K.H. and Koster, F.W. (1999). The State of Exploited Fish Stocks in the Atlantic Sector of the Southern Ocean. Antarctic Ecosystems. Ecological Change and Conservation. Berlin, Springer-Verlag: p309-322.

Koeller, P., Savard, L., Parsons, D., and Fu., C. (2000). A Precautionary approach to Assessment and Management of Shrimp Stocks in the Northwest Atlantic. Journal of Northwest Atlantic Fishery Science 27: p235-246.

Kurtz, J., Jackson, L., & Fisher, W. (2001) Strategies for evaluating indicators based on guidelines from the Environmental Protection Agency's Office of Research and Development. Ecological Indicators 1 (2001), p49-20.

Lane, D., & Stephenson, R. (1996). Fisheries Management Science: Integrating the roles of science, economics, sociology, and politics in effective fisheries management. 2nd World Fisheries Congress: Developing and Sustaining World Fisheries Resources - The State of the Science and Management, Brisbane, CSIRO Publishing. p253-260.

Lane, D., and Stephenson, R. (1999). Fisheries Management Science: a framework for the implementation of fisheries management systems. ICES Journal of Marine Science. 56: p1056-1066.

Lane, D., and Stephenson, R. (2000). Institutional arrangements for fisheries: alternate structures and impediments to change. Marine Policy 24: 385-393.

Larcombe, J., Brooks, K., Charalambou, C., Fenton, M., Fisher, M., Kinloch, M., Summerson, R. (2002). Marine Matters: Atlas of marine activities and coastal communities in Australia's South-East Marine Region. Canberra, Bureau of Rural Sciences**:** 188p.

Larkin, P. (1977). An Epitaph for the concept of Maximum Sustainable Yield. Transcript of the American Fisheries Society. 106: p1-11.

Lugten, G. (1997). The Rise and Fall of the Patagonian Toothfish - Food for Thought. Environmental Policy and law 27(5): p401-406.

Lumley, S. (1999). Interpreting Economics, Rhetoric and Sustainable Development: some implications for policy determination. Australian Geographer 30(1).

Mace, P. M. (1996). 2nd World Fisheries Congress: Developing and Sustaining World Fisheries Resources -The State of the Science and Management. 2nd World Fisheries Congress: Developing and Sustaining World Fisheries, Brisbane, CSIRO.

Mackie, T. (1995). The Comparative Method. In: Theory and methods in Political Science. D. S. Marsh, G. New York, St Martins Press Inc. p65-78

Meadows, D. (1998). Indicators and Information System for Sustainable Development. Dartmouth, The Sustainability Institute**:** 95pp.

Ministry of Fisheries (1996). Changing Course - Towards Fisheries 2010. Wellington, Ministry of Fisheries, New Zealand**:** 25p.

Ministry of Fisheries (2001a). Fisheries Plans Part A: Framework for Developing a Plan. Consultation Document. Wellington, Ministry of Fisheries**:** 54p.

Ministry of Fisheries (2001b). Fisheries Plans Part B : Linkages to Government Processes. Consultation Document. Wellington., Ministry of Fisheries, New Zealand.**:** 29p.

Ministry of Fisheries (2001c). Framework for developing a Fisheries Management Plan. Wellington, Ministry of Fisheries**:** 52p.

Ministry of Fisheries (2001d). Introduction to Fisheries Management Plans: Consultation Document. Wellington, Ministry of Fisheries, New Zealand**:** 22p.

Ministry of Fisheries (2001e). Review of sustainability measures and other management controls for the 2001–02 fishing year. Wellington, Ministry of Fisheries, New Zealand.**:** 22p.

Ministry of Fisheries (2001f). Ringing in the Changes: the Fisheries Act 1996. Wellington, Ministry of Fisheries**:** 8p.

Ministry of Fisheries (2002a). Environmental Performance Indicators Program: Fish Stocks Indicators, Ministry for the Environment: EPI Program. Cited 2002. http://www.mfish.govt.nz

Ministry of Fisheries (2002b). Ministry of Fisheries Homepage., Ministry of Fisheries, New Zealand. 2002. Cited from: http://www.mfish.govt.nz

Ministry for the Environment (1995) Environment 2010: A Statement of the Government's Strategy on the Environment. Wellington, Ministry for the Environment, New Zealand**:** 63p.

Ministry for the Environment (1997). New Zealand's State of the Environment Report 1997. Wellington, New Zealand Government, Ministry of the Environment.**:** 120p.

Ministry for the Environment (1998). Environmental Performance Indicators: Proposed Indicators for the Marine Environment. Wellington, Ministry for the Environment, New Zealand: 150p.

Ministry for the Environment (2001). Environmental Performance Indicators: Confirmed Indicators for the Marine Environment. Wellington, Ministry for the Environment, New Zealand.**:** 62p.

Ministry for the Environment (2002a). Environmental Performance Indicators, Ministry for the Environment, New Zealand. Cited 2002. http://www.environment.govt.nz/indicators/

Ministry for the Environment (2002b). The Resource Management Act., Ministry for the Environment, New Zealand. Cited 2002. http://www.Ministry for the Environment.govt.nz/management/act.htm

Ministry for the Environment (2002c). Creating our future: Sustainable development for New Zealand. Wellington, Parliamentary Commissioner for the Environment, New Zealand: 185p.

Mfodwo, K. (1998). Non-Governmental Initiatives in Global Environmental Responsibility: A Review of the WWF/Unilever Marine Stewardship Council Proposal. International Conference on Environmental Justice and Market Mechanisms: Key Challenges for Environmental Law and Policy, Auckland, New Zealand. 22p.

Mfodwo, K. (2000). Overview of Certification Schemes in Selected Fisheries. Seminar on Trade measures and International Fisheries Management., Antarctic CRC, Hobart, Australia.15p.

Miles, M. H. (2000). Qualitative Data Analysis. London, Sage Publications.

Miller, D. (2002). Antarctic Krill and ecosystem management - from Seattle to Siena. CCAMLR Science 9: p175-212.

Miller, W. L. (1995). Quantitative methods. Theory and methods in Political Science. D. S. Marsh, G. New York, St Martins Press.

Ministerial Advisory Group on Oceans Policy (2001). Healthy Sea, Healthy Society: Towards an Oceans Policy for New Zealand. Wellington, Ministerial Advisory Group on Oceans Policy**:** 66.

Mitchell, P. (2002). Sustainable Development: Comparison of Australian and International Best Practices. Sydney, Environmental Resources Management Ltd**:** 12p.

Moldan, B. (1997). Sustainability Indicators: Report on the Project on Indicators of Sustainable Development. West Sussex, Scientific Committee on Problems of the Environment (SCOPE): 320p.

Moody Marine Ltd (2002). South Georgia and South Sandwich Islands Patagonian Toothfish Fishery MSC Certification Final Report. London, Moody Marine and the MSC: 50pp.

MSC (1998a) MSC Certification Methodology. Annexes A-E. Issue 1. London, Marine Stewardship Council: 22p.

MSC (1998b). Principles and Criteria for Sustainable Fishing. Washington, USA, Marine Stewardship Council: 11p.

MSC (1999). Position Paper to the Seventh Session of the UN Commission on Sustainable Development 1999. Marine Stewardship Council. 4p.

MSC (2000a). An International Coalition of Support. London, Marine Stewardship Council: 2.

MSC (2000b). Conclusions of the MSC Governance Review. London, Marine Stewardship Council: 6pp.

MSC (2001a). MSC Certification Methodology. Issue 3. London, Marine Stewardship Council: 39pp.

MSC (2001b). The MSC Program: Certifying seafood on its journey from the fishery to the consumer. London, Marine Stewardship Council.5p

MSC (2001c). Our Empty Seas: Will there be Fish Forever? London, Marine Stewardship Council: 9pp.

MSC (2001d). An Overview of the Scoring Procedures Used Within the MSC Certification Process. London, Marine Stewardship Council: 4pp.

MSC (2002). MSC Annual Report: 2002. London, Marine Stewardship Council: 35p.

MSC (2003). Marine Stewardship Council Homepage. Matinée Sound & Vision Ltd. Cited 01.2003. http:www.msc.org

Murawski, S. (2000). Definitions of overfishing from an ecosystem perspective. ICES Journal of Marine Science 57: p649-658.

National Policy Committee (2001). Improving Management Processes for Canada's Fisheries: Risk Management and Scientific Support. Ottawa, NPC and DFO.32p.

Nicol, S. (1991). CCAMLR and it's approaches to the management of the Krill Fishery. Polar Record 27: 229-236.

Nicol, S., and de la Mare, W. (1993). Ecosystem management and the Antarctic Krill. American Scientist. 81:36-47.

Nicol, S., and Endo, Y. (1999). Krill Fisheries: Development, management, and ecosystem implications. Aquatic Living Resources 12(2): 105-120.

NRTEE, Nation Round Table on Environment and Economy. (1996). NRTEE Ocean Environment and Resources Task Force Round Table Summary. Stevenson, B., National Round Table on Environment and Economy: 37p.

NRTEE Steering Group (2001). NRTEE Indicators Overview Paper and Stakeholder Workshop. Ottawa, National Round Table on Environment and Economy ESDI Initiative: 9.

NRTEE (2002a). Environment and Sustainable Development Indicators Initiative Progress Bulletin #3. Ottawa, National Round Table on Environment and Economy: 7p.

NRTEE (2002b). Summary Document for Cluster Group Recommendations. Ottawa, National Round Table on Environment and Economy**:** 12.

NRTEE (2002c). Environment and Sustainable Development Indicators Initiative Progress Bulletin #4. Ottawa, National Round Table on Environment and Economy**:** 7p.

NRTEE (2003). Environment and Sustainable Development Indicators for Canada - State of the Debate. Ottawa, National Round Table on Environment and Economy**:** 92p.

Oakley, G. (1997). Sustainable Development Indicators in Australia: Progress on their Development. Conference of European Statisticians: Joint Eurostat Work Session on Methodological Issues of Environment Statistics., Switzerland, Eurostat.17p.

Ocean98 (1998). Oceans Facts and Figures, Oceans98 and International Oceanographic Commission. Cited 2003: http://www.ocean98.org/ocean98.html

OECD (1993a). Environmental Information Systems and Indicators, A Review of Selected Central and Eastern European Countries. Paris, Organisation for Economic Cooperation and Development.

OECD (1993b). OECD Core Set of Indicators for Environmental Performance Review. Paris, Organisation for Economic Cooperation and Development**:** 39p.

OECD (1997a). OECD Environmental Performance Reviews: A Practical Application. Paris, OECD**:** 60p.

OECD (1997b) Towards Sustainable Fisheries: Economic Aspects of the Management of Living Marine Resources. Paris, OECD**:** 175p

OECD (2001a). Key Environmental Indicators. Paris, OECD**:** 36p.

OECD (2001b). OECD Environment Home Page. OECD. Cited 2001. http://www1.oecd.org/env/indicators

OECD (2001c). Sustainable Development: Critical Issues. OECD Ministerial Roundtable. 2002. http://www.oecd.org/oecd/pages/document/

OECD (2001d). Towards Sustainable Development: Environmental Indicators 2001. Paris, OECD.26p.

OECD (1994a). Environmental Indicators. Paris, OECD. 65p.

OECD (1994b). Environmental Indicators: OECD Core Set. Paris, OECD**:** 113p.

Opeskin, B. (1997). The Law of the Sea. Public International Law: An Australian Perspective. S. Blay, Piotrowicz, R., Tsamenyi, M. Melbourne, Oxford University Press.145-162p.

O'Riordian, T., & Voisey, H. (1998). The Political Economy of Sustainable Development. Environmental Politics 8(1): 15-20.

Pal, L. (1992). Public Policy Analysis: An Introduction 2nd Edition. Ontario, Nelson Scarborough Ont. 325p.

Parkes, G. (2000). Precautionary Fisheries Management: The CCAMLR approach. Marine Policy 24(2000): 83-94.

Parliamentary Commissioner for the Environment (2002a). Background Paper: Creating Our Future: Sustainable Development for New Zealand. Sustainability Indicators. Wellington, Office of the Parliamentary Commissioner for the Environment, New Zealand Government 88p.

Parliamentary Commissioner for the Environment (2002b). Background Paper: Creating Our Future: Sustainable Development for New Zealand. Government Strategies. Wellington, Office of the Parliamentary Commissioner for the Environment: 32p.

Parsons, W. (1995). Public Policy: In Introduction to the theory and practice of policy analysis. London, Edward Elgar Publishing, Inc.

Pauly, D., Christensen, V., Froese, R., & Palomares, M. (2000). Fishing Down Aquatic Foodwebs. American Scientist 88: p46-51.

Pauly, D., Christensen, V., Guenette, S., Pitcher, T., Sumala, U., Walters, C., Watson, R, & Zeller, D. (2002). Towards sustainability in world fisheries. Nature 418: p689-695.

Peachment, A. W., J. (1993). Policy Education and the Case Study Method. In: Case Studies in Public Policy. A. W. Peachment, J. Perth, Public Sector Research Unit, Curtin University.63-70p.

Perrings, C. (2000). Sustainability Indicators for fisheries in integrated coastal management. Marine and Freshwater Research 51: p513-22.

Pinkerton, E., & Weinstein, M. (1995). Fisheries that Work: Sustainability Through Community-Based Management. Vancouver, David Suzuki Foundation**:** 199p.

Pitcher, T. (2000). Ecosystem goals can reinvigorate fisheries management, help dispute resolution and encourage public support. Fish and Fisheries 1: 99-103.

Pontecorvo, G. (2003) Insularity of scientific disciplines and uncertainty about supply: the two keys to the failure of fisheries management. Marine Policy 27:p69-73.

Potts, T. & Haward, M. (2001). Sustainability Indicator Systems and Australian Fisheries Management. Maritime Studies March April 2001(117): 1-11.

Powell, D. (1989). Antarctic Marine Living Resources and CCAMLR. Antarctica's Future: Continuity or Change?, Hobart, Australia., Australian Institute of International Affairs: p61-71

Productivity Commission (1999). Implementation of Ecologically Sustainable Development by Commonwealth Departments and Agencies. Canberra, Productivity Commission, Ausinfo. 260p.

RAP, Regional Advisory Process (2000). Proceedings of the Fisheries Management Studies Working Group, 12 January 2000. Dartmouth, Nova Scotia., Bedford Institute of Oceanography, Regional Advisory Process.**:** 71p.

RAP, Regional Advisory Process (2001) Proceedings of the Fisheries Management Studies Working Group, 15-16 May and 31st May 2001. Dartmouth, Bedford Institute of Oceanography, Regional Advisory Process.**:** 82p.

Rhydin, N. (1999). Can We Talk Ourselves into Sustainability: The Role of Discourse in the Environmental Policy Process. Environmental Values 8: p467-484.

Rose, R. (1991). Comparing Forms of Comparative Analysis. Political Studies 39: p446-62.

Rothwell, D. (1998). The Antarctic Treaty System and the Southern Ocean. In: Southern Ocean Fishing: Policy Challenges for Australia. Maritime Policy Paper #7. S. Bateman, & Rothwell, D. Wollongong, Centre for Maritime Policy, University of Wollongong. 89p.

Rothwell, D., and Kaye, S. (2001) Australia's Legal Framework for Integrated Oceans and Coastal Management. In: Integrated Oceans Management: Issues in Implementing Australia's Oceans Policy. M. Haward., M. Hobart, Antarctic CRC.11-31p.

Sainsbury, K., & Sumaila, U.R. (2003). Incorporating ecosystem based objectives into management of sustainable marine fisheries, including best practice reference points and use of marine protected areas. Reykjavik Conference on Responsible Fisheries in the Marine Ecosystem., Reykjavik, Iceland.15p.

Salzman, J. (1991). Environmental Labelling in OECD Countries. OECD Report No.1. Paris, OECD.38p.

Saunders, D., Margules, C., & Hill, B. (1998). Environmental indicators for national state of the environment reporting - Biodiversity, Australia: State of the Environment. Canberra, Department of the Environment.68p.

SC-CCAMLR (1984). Report of the Fourth Meeting of the Scientific Committee (SC-CCAMLR-IV). Hobart, Scientific Committee for the Conservation of Antarctic Marine Living Resources.**:** 275pp.

SC-CCAMLR (1985). Report of the Fifth Meeting of the Scientific Committee (SC-CCAMLR-V). Hobart, CCAMLR**:** 238pp.

SC-CCAMLR (2001). Report of the Twentieth Meeting of the Scientific Committee. Hobart, Scientific Committee for the Conservation of Antarctic Marine Living Resources.**:** 576.

SCFA-FRDC Project (2000). SCFA-FRDC ESD Project: Case Study Information Package. Sydney, Australia, Standing Committee on Fisheries and Aquaculture and Fisheries Research and Development Corporation: 64p.

Schram, G (1995). Editorial: The High Seas Commons: Imperative Regulation of Half Our Planet's Surface. Environmental Conservation 22(1).

SeaFIC, Seafood Industry Council NZ (2002). New Zealand Seafood Industry Export Summary, SeaFIC. Cited 2002. http://www.seafood.co.nz/nzseabus.cfm

Sharp, G. (1996). Its About time: Rethinking Fisheries Management. World Fisheries Congress: Developing and Sustaining World Fisheries Resources, Brisbane, CSIRO Publishing. p205-210.

Shearman, R. (1990). The Meaning and Ethics of Sustainability. Environmental Management 14(1): [1-8.

Slater, R. (1991). Conservation in a Changing World. Search 22(8): [267-281.

Smith, A., Sainsbury, K., and Stevens, R.A. (1999). Implementing effective fisheries management systems - management strategy evaluation and the Australian partnership approach. ICES Journal of Marine Science 56: 967-979.

Smith, H. D. (2000). The Industrialisation of the World Ocean. Ocean and Coastal Management 43: p11-28.

Smith, S. (2001). A Proposed Approach to Environment and Sustainable Development Indicators Based on Capital. NRTEE ESDI Initiative. 2002.

Smith, R (2003). The Role of Institutions in Building Frameworks to Measure Sustainable Development: The Canadian Experience. Workshop on Accounting Frameworks to Measure Sustainable Development. May 14-16, Paris. Environment Accounts and Statistics Division; Statistics Canada. OECD

Staples, D. (1996). Indicators of Sustainable Fisheries Development. 2nd World Fisheries Congress: Developing and Sustaining World Fisheries Resources: The State of Science and Management., Brisbane, Australia, CSIRO Publishing.719-726p.

Statistics New Zealand (2002a). Agriculture, Forestry and Fishing Statistics and Overview. Statistics New Zealand. Cited 2002. http://www.stats.govt.nz/

Statistics New Zealand (2002b). Monitoring Progress Towards a Sustainable New Zealand: An experimental report and analysis. Wellington, Statistics New Zealand**:** 98p

Stokes, A. (1999). Property Rights on the High Seas: Issues for High Seas Fisheries. Fishrights99, Fremantle, Western Australia, Department of Agriculture, Fisheries and Forestry - Australia.18p.

Stokke, . (2000). Managing straddling stocks: the interplay of global and regional regimes. Ocean and Coastal Management 43: p205-234.

Stone, C. (1997). The crisis in global fisheries: can trade laws provide a cure? Environmental Conservation 24(2): 2.

Stratos Consulting Inc. (2002). NRTEE ESDI: Steering Committee Synthesis Report. Ottawa, NRTEE**:** 46p.

Stroud, R. H. (1975). Introductory remarks. Optimum Sustainable Yield as a Concept in Fisheries Management. Roedal, P. American Fisheries Society Special Publication. 9**:** p89.

Sustainable Fisheries Section (2002). EA Catch Up. Environment Australia.4p.

Sutton, M. (1996). A new paradigm for managing marine fisheries in the next millennium. World Fisheries Congress: Developing and Sustaining World Fisheries Resources., Brisbane, CSIRO Publishing.

Teisl, M. F., Roe, B. & Hicks, R.L. (2002). Can Eco-labels Tune a Market? Evidence from Dolphin-Safe Labelling. Journal of Environmental Economics and Management 43: 339-359.

Townsend, R. (1995). Fisheries self-governance: corporate or cooperative structures? Marine Policy 19(1): 6.

Tsamenyi, M. &. McIlgorm., A. (1996). International Environmental Instruments and their Impact on the Fishing Industry. World Fisheries Congress: Developing and Sustaining World Fisheries Resources., Brisbane, Australia., CSIRO Publishing. p661-667.

United Nations (1993) Agenda 21: Earth's Action Plan. New York, Oceania Publications.

United Nations (2002a). The Johannesburg Declaration on Sustainable Development. Johannesburg, WSSD**:** 4p.

United Nations (2002b). Report of the World Summit on Sustainable Development Johannesburg, 2002. Johannesburg, United Nations**:** 173p.

United Nations (2002c). World Summit on Sustainable Development: Key Outcomes of the Summit. Johannesburg, World Summit on Sustainable Development.

United Nations (2002d). World Summit on Sustainable Development: Plan of Implementation. Johannesburg,, United Nations**:** 54.

UN Commission for Sustainable Development (2002a). Johannesburg Summit 2002. Country Profiles: New Zealand. New York., UN CSD. Cited 2002. http://www.uncsd.org/profiles/nz

UN Commission for Sustainable Development. (2002b). United Nations Sustainable Development: Website on National Information on Sustainable Development. UN CSD. Cited 2002. http://www.uncsd.org

UN Department of Economic and Social Affairs (2001). Indicators of Sustainable Development: Framework and Methodologies. New York, United Nations Commission on Sustainable Development.**:** 294p.

UNDP (2001). Human Development Report 2001: Making New Technologies Work for Human Development. New York, United Nations Development Program**:** 309p.

UNDP (2001). United Nations Development Program: Partnerships to fight poverty., UNDP. 2001.

UNEP (1997). Global Environmental Outlook 1. United Nations Environment Programme, Global State of the Environment Report. Nairobi, UNEP.

UNEP (2002). Global Environmental Outlook 3. United Nations Environment Programme, Global State of the Environment Report. Nairobi. UNEP**:** http://www.grida.no/geo/geo3/english/index.htm.

UNEP (2003). GEO: Global Environmental Outook, United Nations Environment Programme 2003. http://www.grida.no/geo/

Unknown (1996). Strengthening the Application of International Environmental Law. Environmental Policy and Law 26(4): 170-174.

Unknown (2000). Environmental Sustainability Debate Impacts on Fisheries. Fishing Today 13(2): 1-4.

Uphoff, N.(1998). Incentives for avoiding the Tragedy of the Commons. Environmental Conservation 25(3): 251-261.

Upreti, G. (1994). Environmental Conservation and Sustainable Development Require a New Development Approach. Environmental Conservation 21(1): p18-29.

Vandermullen, H. (1998). The development of marine indicators for coastal zone management. Ocean and Coastal Management 39:p63-71.

Vandermullen, H. (2002). An Operational Framework for Marine Environmental Quality Under the Oceans Act: National Technical Support, Performance Measurement and Guidance on the Ecosystem Approach for Integrated Management and Marine Protected Areas. Ottawa, Fisheries and Oceans Canada**:** 38p.

Vandermullen, H., & Cobb, D. (2001). Marine Environmental Quality: A Canadian Perspective. Canadian Journal of Fisheries and Aquatic Sciences.18p.

Venning, J. (2001). Introduction: Emerging Systems for Informing Sustainable Development. In: Towards Sustainability: Emerging Systems for Informing Sustainable Development. Venning, J & Higgins, J. Sydney, UNSW Press.1-22p.

Vidas, D. (2000). Emerging Law of the Sea issues in the Antarctic Maritime Area: A Heritage for the New Century? Ocean Development and International Law 31: 197-222.

Vojnovic, I. (1995). Intergenerational and Intergenerational Equity Requirements for Sustainability. Environmental Conservation 22(3): p223-227.

Walton, D. (1987). Antarctic Science. Cambridge, Cambridge University Press. 234p

Ward, T. (1998). Achieving the Preferred Future for Our Ocean Ecosystems. Seaviews Conference: Marine Ecosystem Management: obligations and opportunities., Wellington, New Zealand., ECO New Zealand: 25-32p.

Ward, T. (2000). Indicators for assessing the sustainability of Australia's marine ecosystems. Marine Freshwater Research 51: 435-46.

Ward, T. (2001). Scoping Review: New Zealand Environmental Management Strategy. Seaviews Conference. Wellington, Institute for Regional Development, University of Western Australia**:** 45p.

Ward, T., Butler, E., & Hill, B. (1998). Environmental Indicators for national state of the environment reporting - Estuaries and the Sea. Canberra, Department of the Environment.**:** 79p.

Ward, T., Tarte, D., Hergerl, E., & Short, K. (2002). Policy Proposals and Operational Guidance for Ecosystem-Based Management of Marine Capture Fisheries. Sydney, World Wide Fund For Nature**:** 98.

WCED, World Commission on Environment and Development (1987). Our Common Future: World Commission on Environment and Development. Oxford**:** 400p.

Weeber, B. (1998). Ecosystem Management Principles: New Zealand's Marine Legal Framework. Seaviews Conference, New Zealand, Environment and Conservation Organisations. 9p

Welch, K. (1998). The Patagonian Toothfish: Its Life, Its Death and Its Managers. Institute of Antarctic and Southern Ocean Studies. Hobart, University of Tasmania: 50.

Weller, P. (1980). The Study of Policy. Australian Journal of Public Administration. 3/4: 499-507.

WGEM, Working Group on Ecosystem Monitoring and Management. (2002). Report of the WG-EMM 2002. Big Sky, Montanna: CCAMLR**:** 195pp.

Whitworth, B., Chesson, J., and Smith., T. (2000). Reporting on Ecologically Sustainable Development in Commonwealth fisheries. Canberra, Bureau of Rural Sciences**:** 98p.

Wijkman, A. (1999). Sustainable development requires integrated approaches: A world in transition. Policy Sciences 32: 343-350.

Willock, A. (2002). Uncharted Waters. Implementation issues and potential benefits of listing Toothfish in Appendix II of CITES., TRAFFIC: 36p.

Wilson, R.., Harding, L., and Hirvonen, H. (1995). Marine ecosystem monitoring network design. Ecosystem Health 1: 222-2227

World Bank (1995). Monitoring Environmental Progress: A Report on Work in Progress. Washington, The World Bank.

World Bank (1997a). Expanding the Measure of Wealth. Washington, The World Bank**:** 110.

World Bank (1997b). Five Years after Rio: Innovations in Environmental Policy. Washington, The World Bank, Environment Department**:** 54p.

World Bank (2001). The Little Green Data Book 2001. Washington, The World Bank**:** 230p.

World Bank, (2002). Environmental Indicators: An Overview of Selected Indicators at the World Bank. Washington, World Bank - Environment Department**:** 5p.

WWF (1999). Certification of Sustainable Fishing Practices. Melbourne, World Wide Fund For Nature.4p.

WWF (2002). WSSD: Does it go far enough? Surrey, WWF. 12p.

WWF (1998). The Footprint of Distant Water Fleets on World Fisheries. Surrey, WWF**:** 169p.

Yuile, P., and Stokes, A. (2000). Beyond the EEZ - Regional management of high seas stocks and opportunities for Australia. Outlook 2000: Proceedings of the National Outlook Conference, Natural Resources. ABARE. Canberra, ABARE**:** p239-253.

5NR MOU Working Group. (2001). A Vision For Federal State of the Environment Reporting in Canada. Ottawa, Environment Canada.