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Issues of Sustainability in the Southern Ocean Fisheries – the Case of the Patagonian Toothfish

Patagonian toothfish (*Dissostichus eleginoides*) © CSIRO Marine Research

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Acronyms and Abbreviations

AAD – Australian Antarctic Division

AFMA – Australian Fisheries Management Authority

ASOC – Antarctic and Southern Ocean Coalition

ATCP – Antarctic Treaty Consultative Party

ATS – Antarctic Treaty System

BIOMASS – Biological Investigation of Antarctic Systems and Stocks

BSD – Bluefin Tuna Statistical Document Program

CCAMLR – Convention for the Conservation of Antarctic Marine Living Resources

CCAS – Convention on the Conservation of Antarctic Seals

CDS – Catch Documentation Scheme

CITES – Convention on International Trade in Endangered Species of Wild Fauna and Flora

CQFE – Centre for Quantitative Fisheries Ecology

CRAMRA – Convention on the Regulation of Antarctic Mineral Resource Activities

CSIRO – Australian Commonwealth Scientific and Industrial Research Organisation

EEZ – Exclusive Economic Zone

FAO – Food and Agriculture Organisation

HCDCS – Harmonized Commodity Description and Coding System

ICRW – International Convention for the Regulation of Whaling

IABO – International Association of Biological Oceanography

ICCAT – International Commission for the Conservation of Atlantic Tunas

ICSU – International Council of Scientific Unions

IGY – International Geophysical Year

IOC – Intergovernmental Oceanographic Commission

IPOA – International Plan of Action

ISOFISH – International Southern Oceans Longline Fisheries Information Clearing House

IUU – Illegal, Unreported and Unregulated

IWC – International Whaling Commission

LOSC – United Nations Convention on Law of the Sea

NGO – Non-government Organisation

NMFS – National Marine Fisheries Service

SCAR – Scientific Committee on Antarctic Research

SC-CCAMLR – Scientific Advisory Committee (CCAMLR)

SCOR – Scientific Committee on Oceanographic Research

TAC – Total Allowable Catch

The Compliance Agreement – International Conservation and Management Measures by Fishing Vessels on the High Seas

The Madrid Protocol – Protocol on Environmental Protection on the Antarctic Treaty

TRAFFIC – Trade Records Analysis of Flora and Fauna in International Commerce

UNFSA – Conservation and Management of High Seas Straddling Fish Stocks and Highly Migratory Fish Stocks (the Fish Stocks Agreement)

VMS – Vessel Monitoring System

WG-FSA – Working Group for Fish Stock Assessment (CCAMLR)

WG-IMAG – Working Group on Incidental Mortality Arising from Fishing (CCAMLR)

WWF – World Wildlife Fund

1 Introduction

The Southern Ocean is a hostile and remote marine environment. It is also a place of great beauty that contains unique fish, bird, mammal and coral species, and thousands of invertebrates, plants and micro-organisms – many of which we know little about or which are endemic and occur nowhere else in the world.

The Southern Ocean also contains a wealth of natural marine resources that include the Patagonian toothfish (*Dissostichus eleginoides*) fishery. This fishery has come under increasing pressure over the last decade as fishers have harvested stocks to meet the demands of an increasing world population and an insatiable desire by consumers to eat white-fleshed fish (Fallon and Kriwoken *submitted*). Given the demand for Patagonian toothfish, illegal fishing of these stocks has flourished and the incidental mortality of seabirds in this longline fishery threatens many endangered albatross species. In addition, discarded longline equipment threatens marine mammals when they become entangled in the lines.

This report focuses on issues of sustainability in the Southern Oceans fisheries, with specific reference to the Patagonian toothfish. The paper also informs a series of companion Internet sites that summarise the findings reported in detail here and they can be accessed at <http://www.lighthouse-foundation.org/>.

A description of the Southern Ocean, and its physical and biological characteristics, sets the scene for a related discussion about its marine resources. We then outline the historical and contemporary context of the Southern Ocean's management, and elaborate on the range of fishing techniques used to harvest a number of fisheries. With this important background information in place, we examine the case of the Patagonian toothfish describing its ecology, stock estimates and commercial exploitation. An analysis of the incidence of illegal, unreported and unregulated (IUU) fishing then leads to a discussion of trade in Patagonian toothfish. What becomes clear from this work is that there are various international actors of influence whose involvement in the Southern Ocean fisheries is crucial for sustainability outcomes and for the conservation of the Patagonian toothfish and other species in the Southern Ocean.

1.1 The Southern Ocean

The Southern Ocean was identified and named by Captain James Cook in the 1760s and its discovery predated that of Antarctica. This ocean constitutes about 15 per cent of the world's total ocean surface (Miller 1991) and has a total area of about 28 million square kilometres (Stonehouse 2002). It is a large, unbroken and dynamic water body that connects a series of semi-closed interconnected ecosystems (Scott 1994). It comprises three major oceans: the Pacific, Atlantic and Indian Oceans. The Antarctic continent forms its southern boundary. The northern boundary is more vaguely defined although it is generally taken to be more or less south of 47°S.

The Southern Ocean is annular or ring shaped. The Antarctic continent is the central land mass and the tips of three continents intrude upon it. These land masses and a scattering of islands and other suboceanic features form focal points for local hydrographic effects. The Southern Ocean narrows between the Antarctic Peninsula and South America, and it is the only significant feature to impede the Southern Ocean's major wind and current systems. These systems are circumpolar and there is a marked coriolus effect due to the earth's rotation.

1.2 Antarctic Convergence

The Antarctic Convergence (or Antarctic Polar Front) surrounds the ocean at its northern boundary at between 50°S to 60°S and it is a major oceanographic and biological boundary (Scott 1994). This is a relatively narrow zone of water approximately 50 kilometres wide where cold, less saline, northward-flowing Antarctic water slides under the warmer, southward-flowing, sub-Antarctic waters of the Atlantic, Indian and Pacific Oceans. Macquarie Island and the Kerguelen, Crozet and Prince Edward islands lie in, or near, the Antarctic Convergence and they are usually considered to be part of the Southern Ocean.

1.3 Bathymetry of the Southern Ocean

The Southern Ocean has great variations in depth although the mean depth is close to 4000 m (Stonehouse 2002). The greatest depths (South Sandwich Trench) exceed 8000 m. Shelf areas surround the islands groups and Antarctic continent. In addition, banks and chasms promote upwelling of nutrients that provide food for other species including finfish. Given the local concentration of biota near these nutrient-rich features, they can be the focus of commercial harvesting operations.

This ocean consists of a system of deep basins separated by three large mid-oceanic ridges (CCAMLR 2002a). The Macquarie Ridge is found south of New Zealand and Tasmania; the Kerguelen–Gaussberg Ridge at about 80°E; and the Scotia Ridge (or Scotia Arc) extends from the southern Patagonian shelf in an eastward arc to the South Shetland Islands and the Antarctic Peninsula. Around the Antarctic continent, the continental shelf is narrow, except in parts of the Weddell, Ross, Amundsen and Bellingshausen Seas and it covers up to 5 per cent of the total area of the Southern Ocean.

1.4 Current systems in the Southern Ocean

There are two important circumpolar currents that affect the upper layers in the Southern Ocean. The eastward-flowing Antarctic Circumpolar Current (West Wind Drift) connects the Pacific, Indian and Atlantic oceans. It flows more or less continuously in the north close to the Antarctic Convergence and is the largest ocean current in the world (CSIRO 2000; Scott 1994). This current passes through the Drake Passage, and moves north along the Patagonian Shelf to meet the Brazil

Current, then flowing eastward across the Atlantic. In the Indian Ocean, the current passes along the Crozet and Kerguelen Island groups, to meet the Macquarie Ridge before splitting into two off the Campbell Plateau south of New Zealand. Extensive mixing with Pacific Waters occurs until the current returns to the Drake Passage. Near the Antarctic continent, the more discontinuous westward-moving East Wind Drift is broken into a series of clockwise gyres and local eddy systems close to the continental margin, such as the Weddell Sea Gyre (Miller 1991). These fronts mark large changes in temperature and salinity and they may also act as conveyers for transporting finfish around the Southern Ocean.

In vertical section, thermohaline instability (or water movement that is attributed to differences in temperature and salinity) among the three major water masses (Antarctic Surface, Intermediate and Bottom Water) induces periodic upwelling of nutrients, especially in the boundary regions between the East and West Wind Drifts (the Antarctic Divergence) (Miller 1991). These vertical differences are important because they influence the Southern Ocean's biological productivity as a whole.

1.5 Weather and climate in the Southern Ocean

The Southern Ocean significantly affects world climates in three ways (CSIRO 2000). Firstly, the Antarctic Circumpolar Current redistributes heat and other properties globally. This redistribution influences temperature and rainfall patterns. Secondly, this ocean's intermediate and deep waters renew the world's other oceans. For example, the cooling of the Southern Ocean and formation of sea-ice during winter increase the water's density, which sinks from the sea surface into the deep-sea to control the physical and chemical properties of the deep-sea waters. Thirdly, water exchanges gases such as oxygen and carbon dioxide with the atmosphere at the sea surface, while being cooled. As this water sinks, it efficiently transfers heat, freshwater and absorbed gases from the atmosphere (including carbon released into the atmosphere by the burning of fossil fuels and deforestation) into the deep ocean.

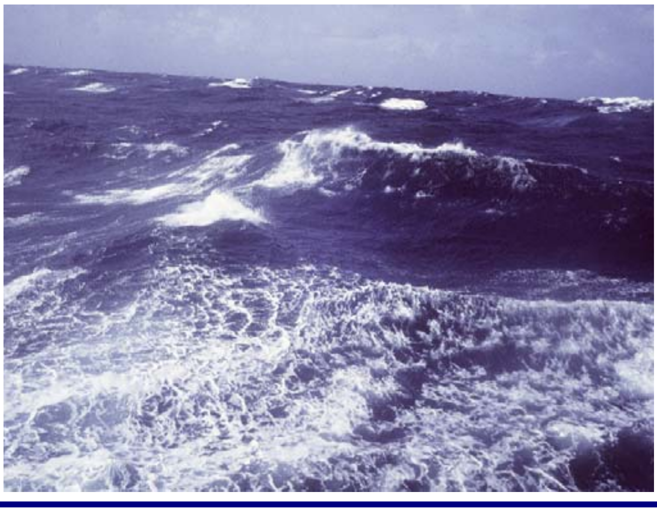


Plate 1.1: The Southern Ocean © Christine Materia-Rowland

In addition, there are few impediments to airflow and winds over the ocean's surface reaching high velocities and generating very large ocean waves (Plate 1.1). Wave heights are often over 5 m, particularly between the latitudes of 45°S and 60°S in the Indian Ocean and parts of the Eastern Pacific.

1.6 Biological zonation in the Southern Ocean

Antarctica is surrounded by sea ice for most of the year. The southern two-thirds of the ocean's freezing surface water freezes during winter to depths of one-two metres, forming floating sea-ice (Stonehouse 2002). Some is attached to the land (fast ice) and rest drifts with the wind and currents (pack ice). Breaks are found in the sea ice where leads (fissures in the ice) and polynyas (enclosed areas of unfrozen water surrounded by ice) allow exchange of gases and provide access to the water surface for marine species. The maximum extent of sea ice is approximately 20 million square kilometres during September-October (Stonehouse 2002). The minimum sea ice cover is approximately four million square kilometres during February-March.

Winds, currents, salinity and water temperatures combine in some areas of the Antarctic and Arctic to produce areas where there is no ice, or comparatively thin ice, during the winter. These polynyas recur year after year in the same places, although the exact boundaries vary with the particular conditions prevalent each year (see also Simon 1982). Extensive polynyas are found in northern Baffin Bay (the North Water Polynya) and near Cape Bathurst in the eastern Beaufort Sea. Some polynyas normally form for short periods in the early spring. In Antarctica, they form close to the coast, maintained by strong systemic or katabatic winds (Stonehouse 2002).

By providing open water throughout winter and spring, polynyas are places where whales, walruses, certain seals and seabirds can survive. During this time their presence in areas such as the Canadian Arctic is restricted for lack of places to breathe because of thick ice cover on the sea. The survival of animals over-wintering in polynyas is dependent on the water remaining open, as they have no way of escape.

The Southern Ocean is generally a region of low biological productivity. However, concentrations of high productivity are associated with the presence of sea ice, particularly at the ice edge. Combined with (i) regions of upwelling or current borne nutrient-bearing water, (ii) sub-marine regions such as continental shelves, (iii) the marked seasonal cycle of solar illumination and (iv) stable water conditions near the sea surface, sea ice regulates the phytoplankton production on which all forms of marine life depend (Miller 1991; El-Sayed 1978). In addition, the richness and diversity of benthic (or bottom dwelling) fauna are comparable to those of tropical regions, with a large number of long-lived and slow-growing forms present in the Southern Ocean (CCAMLR 2002a).

Three major ecological zones, each with its own assemblage of species, can be distinguished in the Southern Ocean:

1. ice-free zone,
2. seasonal pack-ice zone, and
3. permanent ice zone or high-latitude Antarctic zone.

The ice-free zone lies between the Antarctic Convergence and the northern limit of the pack ice in winter. Many organisms do not move north of the Antarctic Convergence and its effects are relatively shallow – to about 300-500 m. This zone is characterised by the presence of slaps, copepods and euphausid crustaceans (Hosie 1994; Kock 1992).

The intermediate seasonal pack-ice zone is ice-covered in winter and spring. This zone is the most productive of the three, with the highest primary productivity of phytoplankton (Hempel 1987). It also has the highest commercial concentrations of Antarctic krill (*Euphausia superba*) and this is the dominant planktonic organism and staple food of many whales, seals, birds and fish.

The permanent ice zone or high-latitude Antarctic zone is adjacent to the Antarctic continent and remains ice covered for most of the year. The smaller and less abundant Ice krill (*Euphausia crystallorophias* and *Thysanoessa macrura*) and the pelagic Antarctic silverfish (*Pleuragramma antarcticum)* are found in this shallow (or neritic) zone.

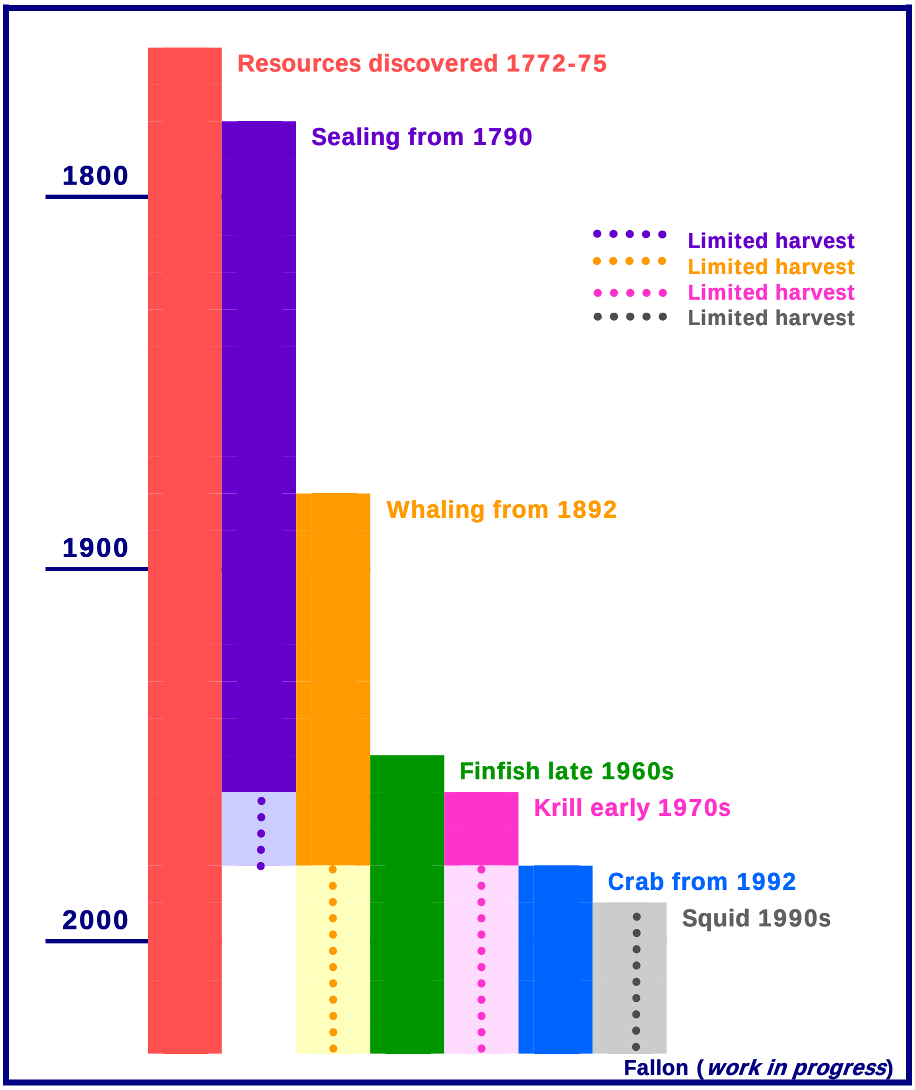
2 Southern Ocean marine resources

2.1 The discovery of Southern Ocean marine resources

The major living resources in the Southern Ocean are whales, seals, birds, fish, krill and squid. The use of these resources goes back over two centuries (Agnew and Nicol 1996; Walton 1987) and it has been characterized by the progressive over-harvesting of seals, whales and finfish (Figure 2.1). 'Limited harvest' referred to in Figure 1 denotes either a restricted harvest in seal and whale stocks, reduced harvesting for krill or an exploratory squid fishery.

When Captain Cook crossed the Atlantic Circle and discovered South Georgia between 1772 and 1775 (Kriwoken and Williamson 1993) he reported fur seals in abundance on its beaches (Stonehouse 2002). His discovery marks the beginning of exploitation of marine species in the Southern Ocean with the earliest records of sealing dating from 1786. After this, a major commercial fishing industry developed on sub-Antarctic islands (including South Georgia, Prince Edward, Crozet, Kerguelen and Macquarie islands) in about 1790 when hunters exploited Antarctic fur seals (*Arctocephalus gazella*, *A. tropicalis*). Hunting of southern right whales (*Eubalaena australis*) followed (Kock 1994). Exploitation resulted in seal and whale populations being reduced to very low levels within decades.

Figure 2.1: Commercial exploitation of Southern Ocean marine resources.



By the 1800/01 season, more than 110 000 sealskins were taken on South Georgia alone (CCAMLR 2002a). Harvesting continued into the nineteenth century when hunters discovered seal stocks on the South Shetland Islands in 1819/20 (Agnew and Nicol 1996). By 1825, most populations of Antarctic and sub-Antarctic fur seals were on the verge of extinction and it was not until the 1930s and later that numbers began to increase due to additional krill availability and/or species recovery from earlier exploitation. Sealing ceased at South Georgia in 1964 when the land-based whaling industry with which it was associated collapsed (McElroy 1984).

In the nineteenth century, southern elephant seals (*Mirounga leonina*), southern right whales and some sub-Antarctic penguins were also hunted (Kock 1994). Although birds have not been commercially exploited in the Southern Ocean, sub-Antarctic penguins have been taken for oil in a few cases (Agnew and Nicol 1996). Penguins, including King penguins (*Aptenodytes patagonicus*) and Crested penguins (*Eudyptes spp.*), were exploited for cooking and cosmetic oil, food and as fuel for fire on sub-Antarctic islands such as South Georgia, Heard and Macquarie. For example, on Macquarie Island, 150 000 king penguins were taken between 1895 and 1919 for oil.

Other seal species including Crabeater (*Lobodon carcinophagus*), Weddell (*Leptonychotes weddellii*), Leopard (*Hydrurga leptonyx*) and Ross seals (*Ommatophoca rossii*) were taken regularly in small numbers to feed dog teams or during exploratory sealing in the pack ice (CCAMLR 2002a) (Plate 2.1).

Plate 2.1: Weddell seal © Ben Galbraith

James Weddell raised his concern over indiscriminate sealing

James Weddell (1787-1834), himself a British master mariner, polar explorer and sealer, estimated that 1.2 million fur seals were taken from South Georgia by 1822 (Stonehouse 2002). His observations between 1822 and 1825 led him to recognise that exploitation could not continue indefinitely:

> The system of extermination was practised … whenever a seal reached the beach … he was immediately killed and his skin taken; and by this means, by the end of the second year the animals became nearly extinct; the young having lost their mothers when only three or four days old of course all died … (Weddell 1827:142 as cited in Johanson 1997:15).

Weddell (1827:141 as cited in Johanson 1997:15) proposed that a *law similar to one restraining fishermen in the size of the mesh of their net* would conserve seal populations and ensure that large annual harvests of skins could continue. Unfortunately, most Antarctic and sub-Antarctic fur seals were exterminated on accessible islands by 1825. Weddell published an account of his voyages and recorded observations of weather, tides and natural history (see also Weddell 1825).

It was not until the twentieth century that whaling of all seven species or subspecies of baleen whales (rorquals) and toothed whale (*Physeter macrocephalus*) began. From 1909 to 1964 a controlled harvest of male southern elephant seals for their highly prized oil was undertaken at South Georgia, the Kerguelen Islands, Heard, McDonald and Macquarie islands, as did an exploratory harvesting of ice seals in 1963/64, 1972 and 1986/87 (Kock 1994) (Plate 2.2). The start of fishing for finfish and krill also occurred at this time.

Plate 2.2: Heard Island © Liza Fallon

Commercial whaling stopped in 1982 when the International Whaling Commission (IWC) adopted a moratorium on whale harvesting (Dodds 2000). Unregulated sealing generally stopped in most places within the first two decades of the twentieth century although it has resumed intermittently whenever seal populations have begun recover. The last known sealing in the Antarctic was conducted by the Soviet Union in 1986/87 (Constable 2002). In recent times, exploratory fishing for stone crabs and squid has also begun (Kock 1994). By the 1970s, the introduction and potentially rapid expansion of the krill fishery threatened to impact the marine ecosystem and this fishery was the first to characterise the nature of possible future exploitation of marine species (Nicol and de la Mare 1993).

Plate 2.3: Japanese scientific whale factory ship in Antarctic waters © Damian Flynn

The history of whaling in the Southern Ocean

By the 1830s fur seal populations on islands in the Southern Ocean were so severely depleted that many sealers turned to whaling. The German Whaling and Sealing Expedition in 1873-74 was the earliest expedition to investigate commercial whaling (Stonehouse 2002). However, commercial whaling was initiated in 1892 with Norwegian and British reconnaissance expeditions and started in December 1904 at Grytviken on South Georgia by an Argentine-Norwegian expedition (Agnew and Nicol 1996; McElroy 1984; Tonnessen and Jonse 1982). It then expanded to the more southerly islands of the Scotia Arc and to the Kerguelen Islands within 10 years. Humpback whales (*Megaptera novaeangliae*), favouring inshore regions, were the first to be targeted, followed by blue whales (*Balaenoptera musculus*). By 1937/38, 45 000 whales were taken.

Whaling was land-based until the early 1920s, with processing taking place either at shore stations or alongside factory vessels moored in sheltered fjords and bays (CCAMLR 2002a). It then became an offshore (i.e. pelagic) operation and went beyond the scope of national jurisdictions from 1925, when factory vessels began to be fitted with stern slipways. Pelagic factory ship/catcher operations became the most common type of whaling and the number of factory ships and catcher vessels increased rapidly.

The first attempt at conserving whale stocks in the Southern Ocean was made from 1906-1908 by the British government acting through the Falkland Islands Dependencies government, which at the time also administered South Georgia (Stonehouse 2002; Johanson 1997; Agnew and Nicol 1996). From this time, the British government leased land for whaling stations ands issued licences. For example, in 1912-13 the Deception Island whaling station was built, licensed on a 21-year lease by the Government of Dependencies (Stonehouse 2002). The British government, noting that the South Atlantic was probably the most profitable whaling ground, also claimed the islands of South Georgia, South Orkney, South Sandwich and South Shetland islands, and the tip of the Antarctic Peninsula as part of the Dependencies (Agnew and Nicol 1996). The British government also considered the development of fisheries in conjunction with whaling and sealing around the Falkland Islands and Dependencies and established an *Ordinance to Regulate Sea Fisheries* which remained in force until 1944 (Kock 1992).

In response to rapidly depleting whale stocks, the League of Nations then prohibited the harvesting of right whales off South America, South Africa and Australia in the 1930s (CCAMLR 2002a). In 1946, the International Convention for the Regulation of Whaling (ICRW) was signed (Dodds 2000). The IWC was established in 1948 after ratification of this Convention to regulate whaling and humpback whales (*M. novaeangliae*) were protected in 1963 and blue whales (*B. musculus*) in 1964. Fishers then turned their efforts to hunting minke whales (*B. acutorostrata)* in the 1970s following the reduction of the permitted take of other species. In 1979, all species of baleen whales, except for the minke, were protected in the Southern Ocean and the IWC established the 'Indian Ocean Sanctuary', for the entire Indian Ocean, including the northern waters of the Indian Ocean sector of the Southern Ocean as far south as 55°S (McElroy 1984).

However, the threat to whale populations remained and the whale catch in the Antarctic from 1904 to the 1980s is estimated at more than 1.5 million. In response, the IWC adopted a moratorium on all commercial whaling in 1982 that came into effect after the 1986/87 season (McElroy 1984). Some nations continue to harvest minke whales –Japan, for example, harvests an annual quota of approximately 300 minke whales under a 'scientific whaling' exemption to the moratorium (Agnew and Nicol 1996).

In 1994, the IWC established the 'Southern Ocean Sanctuary' south of 40°S (except for an area of the southeast Pacific–southwest Atlantic to the south of 60°S). Whaling is prohibited here and prohibition will be reviewed in 2004. Japan objected to this sanctuary's establishment and is not bound by the IWC's decision. This nation continues to catch Antarctic whales on scientific grounds under relentless opprobrium from national governments and conservationists (Stone 2002a; Stonehouse 2002) (Plate 2.3).

2.2 Large-scale commercial marine harvesting

According to CCAMLR (2002a) and Kock (1994; 1992) the main species that are, or have, been harvested in the Southern Ocean are Antarctic krill, Patagonian toothfish, Mackerel icefish (*Chamsocephalus gunnari*), Marbled rockcod (*Notothenia rossii*), Grey rockcod (*Lepidonotothen squamifrons*), Antarctic toothfish (*Dissostichus mawsoni*) and Patagonian rockcod (*Patagonotothen guntheri*). These species are described in Table 2.1.

Table 2.1: The main marine species harvested in the Southern Ocean.

Species	Distribution	Size, Age, Weight[1]	Biology	Exploitation	Status
Antarctic Krill (*Euphausia superba*)	Circum-Antarctic in Antarctic surface waters to 100 m south of the Antarctic Convergence	64 mm 6-7 yrs	Matures in 2-3 yrs Spawns Dec-Mar Recruitment linked to pack ice cover Key species	Harvesting started in 1972/73 and peaked in 1981/82 Annual catches are currently estimated at 90 000 to 100 000 t	Unlikely that present levels of fishing will adversely effect stock(s)
Patagonian toothfish (*Dissostichus eleginoides*)	Widely distributed to 3000 m, from the slope waters off Chile and Argentina, around South Africa and New Zealand, to the islands and banks in the sub-Antarctic waters of the Atlantic, Indian and Pacific oceans Southernmost records are for the South Orkney and South Sandwich islands	Up to 238 cm Age estimates for individuals larger than 100 to 120 cm are scarce, however, individuals are likely to be at least 40-50 yrs 130 kg	Matures at 70-95 cm when they are 6 to 9 yrs old Spawns over the continental slope from Jun-Sep Key species	Catches were first reported in 1976/77 and a Russian longline fishing started in 1985 around South Georgia Since 1996, longlining has expanded rapidly into the slope waters of previously unfished islands, banks and seamounts in the Indian and Pacific Ocean sectors	Estimated catches from unregulated and illegal fishing exceeded those from regulated fishing by a factor of 5:1
Mackerel icefish (*Champsocephalus gunnari*)	This shallow-water coastal species to 350 m is found along the Scotia Arc from Shag Rocks and South Georgia in the north, to the Antarctic Peninsula in the south, around Bouvet Island and on the Kerguelen–Heard Plateau	60-66 cm in the Scotia Arc region 45 cm on the Kerguelen–Heard Plateau 12-15 yrs at South Georgia 5-6 yrs at Kerguelen–Heard Plateau	Matures in3 yrs at South Georgia and the Kerguelen Islands, and in 4-5 yrs in the southern Scotia Arc region Spawning in coastal waters from Feb-Jul in the Atlantic Ocean, and from Apr-Sep in the Indian Ocean	A major trawl fishery targeted species for 15-20 yrs after Marbled rockcod stocks were depleted South Orkney and South Shetland Islands fisheries ended in the early 1980s Currently exploited at South Georgia, Heard and Kerguelen islands when a strong year class enters the fishery	South Georgia stocks recovered from exploitation in the 1970s and 1980s – but remained low after a decline following the 1989/90 season South Orkney and South Shetland Islands stocks are fractions of their late 1970s sizes

Species	Distribution	Size, Age, Weight[1]	Biology	Exploitation	Status
Marbled rockcod (*Notothenia rossii*)	Widely distributed around the Antarctic Peninsula and the Scotia Arc, off Prince Edward, Crozet, Kerguelen, Heard, and Macquarie islands, and on Ob and Lena Banks	85-92 cm 15-20 yrs 8-10 kg	Matures in 5-7 yrs Spawns from Apr-Jun at South Georgia, and in Jun-Jul near the Kerguelen Islands	Target species in the late 1960s to early 1970s around South Georgia and the Kerguelen Islands where catches exceeded 100 000 t in some seasons	Although protected for more than 10 yrs, exploited stocks appear to be only fractions of their pre-fishing sizes Beginning to show signs of recovery around the Kerguelen Islands
Grey rockcod (*Lepidonotothen squamifrons*)	Circum-Antarctic distribution to 800 m around the sub-Antarctic islands and seamounts that lie between them	50-55 cm 16-20 yrs 2-3 kg	Matures in 5-9 yrs at South Georgia and the Kerguelen Islands Spawns from Oct-Feb	Exploited commercially off the Kerguelen Islands and Ob and Lena Banks French authorities closed the Kerguelen Islands fishery in the early 1990s and CCAMLR closed the Ob and Lena Banks fisheries in the early 1990s	Third most important species after Marbled rockcod and Mackerel icefish The fisheries remain closed - the Kerguelen Islands stock remains low, and stocks on Ob and Lena Banks and around South Georgia are unknown
Antarctic toothfish (*Dissostichus mawsoni*)	Extends to about 800 m and confined to the waters around the Antarctic continent with a northern limit at about 60°S	180 cm 22-30 yrs 75 kg	Matures at about 70-95 cm Spawn in Aug-Sep	Targeted since 1996/97 by a number of new and exploratory fisheries	The exploratory fisheries are regulated by the CCAMLR[2] Commission
Patagonian rockcod (*Patagonotothen guntheri*)	Found to 350 m mainly on the southern Argentine Patagonian shelf, and off the Falkland/Islas Malvinas and Shag Rocks	23 cm 6 yrs	Matures at about 12-16 cm Spawns from Sep-Oct	Exploited in the Shag Rocks area from 1978/79 to 1989/90 and the fishery was closed by CCAMLR after the stock was depleted	The current status of the stock is unknown

[1]Maximum size and length
[2]Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR)
Fallon (*work in progress*): Adapted from CCAMLR 2002a; Kock 1992

Krill

During the 1960s fishers became interested in other Southern Ocean resources (McElroy 1984). The Soviets undertook their first krill expedition in the 1961/62 season. The first full-scale krill harvesting experiments began in the late 1960s and commercial fishing for Antarctic krill on a commercial scale started in the 1972/73 season among Soviet and Japanese fleets (Rothwell 1998; Nicol and Endo 1997; Nicol and de la Mare 1993; McElroy 1984). The fishery expanded rapidly with fleets from Chile, Poland and South Korea entering the industry, and it soon concentrated in localised areas in the Atlantic Ocean sector, with the main fishing grounds to the east of South Georgia, around the South Orkney Islands and Antarctic Peninsula and off the north coast of the South Shetland Islands (CCAMLR 2002a).

In the first 10 years of Antarctic krill catches, in particular those made by vessels from parts of the Soviet Union, were largely used for animal feed. After peaking in 1981/82, when 500 000 t were taken (Nicol and de la Mare 1993), catches dropped substantially due to problems in processing krill, large scale Soviet fishing until 1991/92 and then, the break-up of the Soviet Union. However, difficulties in processing krill were overcome in the mid-1980s and today: most krill is processed for aquaculture feed, bait and human consumption. According to Kock (1992), it was mainly due to the technological problems associated with catching and processing krill that the fishing effort was diverted to finfishing – with finfishing preceding large-scale krill harvesting by about 5 years.

From 1986/87 to 1990/91, annual catches of krill stabilised at between 350 000 and 400 000 t, which was about 13 per cent of the world catch of crustaceans (CCAMLR 2002a). After Soviet fishers stopped harvesting, catches declined dramatically after 1992 to about 80 000 t per annum. A total of 118 705 t of krill was caught during the 2001/02 season, taken by Japan, Poland, Republic of Korea, Ukraine and the United States (CCAMLR 2002c).

Finfish

Finfishing in the Southern Ocean has paralleled the history of whaling, repeating the pattern of discovery, exploitation and depletion of each new stock.

Finfishing dates back to the early days of land-based whaling at South Georgia in 1906 (Kock 1994). However, commercial operations are a recent development dating from the time that Soviet fleets began harvesting finfish around the Antarctic Peninsula and nearby islands in 1967 (Nicol and de la Mare 1993). Substantial exploitation began in 1969 when Soviet and other Eastern Bloc fishing operations expanded and targeted the bottom dwelling Marbled rockcod, and the shallow dwelling Mackerel icefish in the South Atlantic, particularly around South Georgia and the Kerguelen Islands (Constable 2002; Kock 1994; Kock *et al.* 1985). In two years from 1969, the Marbled rockcod had almost disappeared from around South Georgia and by the end of 1980 this species was depleted throughout the Southern Ocean.

When exploitation began, national governments were not required to report catches from fishing areas and consequently little is known about the historical size, ecology and extent of these fisheries. Despite this lack of information, it is estimated that downwards trends in fish stocks primarily reflect large-scale harvesting impacts and of the 270 known Southern Ocean species, 12 species are, or have been, subject to commercial exploitation (Agnew 1997; Kock and Shimadzu 1994). For example, after Marbled cod catches were reduced to low levels within a few short years on the Kerguelen Plateau, only Mackerel icefish and Patagonian toothfish had sufficiently large populations to support this region's fisheries (Williams and de la Mare 1995). By the late 1970s, many fish stocks had been overexploited and were unable to sustain further harvesting. The fishing fleets then turned their attention towards harvesting krill (Nicol and de la Mare 1993; Nicol 1991).

Until 1990, commercial finfishing fleets were almost entirely from Eastern Bloc countries and it is estimated that the Soviet Union took more than 85 per cent of the catches (Kock 1994). Since 1990/91, other nations have participated, with France, Chile, Argentina and Ukraine taking the majority of the catch in the regulated fishery.

After most of the demersal (bottom-dwelling) fish stocks were depleted, benthopelagic (living off the bottom) and mesopelagic (living in oceanic midwater) began to be harvested in the second half of the 1980s. These species included Patagonian toothfish and sub-Antarctic lanternfish (indiscriminately recorded as *Electrona carlsbergi)*. By the end of the 1980s, fishing for most species was either prohibited, as in the case of the Marbled rockcod, or limited by total allowable catches (TACs) set by the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) Commission.

Some stocks, such as the bycatch species around South Georgia, appear to have recovered from overexploitation to a certain extent, whereas others, such as the Marbled rockcod, show little sign of recovery in most areas.

By the end of the 1996/97 season, CCAMLR (2002a) estimates that over three million tonnes of finfish had been taken from the Southern Ocean. About two million tonnes were caught in the Atlantic Ocean sector, with over 80 per cent being taken from close to South Georgia. Of the 924 000 t caught in the Indian Ocean sector, nearly 95 per cent was taken near the Kerguelen Islands.

Today, the most important Southern Ocean fisheries are located along the Scotia Arc, Ob and Lena Seamounts, Crozet Islands and the Kerguelen Plateau (Knox 1994; Agnew 1997; Agnew and Phegan 1995). Two main species are currently exploited – the Patagonian toothfish and Mackerel icefish.

Patagonian toothfish, also known as Mero, Chilean Sea Bass, Black Hake and ‘white gold’, is the most valuable fishery in Antarctic or sub-Antarctic waters (Fallon and Kriwoken *submitted*) (Plate 2.4). Patagonian toothfish is circumpolar in its distribution and it is found on and around continental shelves throughout large areas of the Southern Ocean, but primarily in the cool temperate and sub-Antarctic waters off southern South America, and the islands and other submarine ridges of the southern Atlantic and Indian Ocean sectors of the Southern Ocean (AAD 2001a). Living in deep waters from 300 m to over 3500 m, this finfish is a large, long-lived (35-80 years), demersal, predatory, deep-sea fish that can grow to a size of over 2 m long and 100 kg in weight (AFMA 2001; CSIRO 1998). The species was originally caught as part of a mixed bottom trawl fishery around South Georgia Island and Shag Rocks.

Plate 2.4: Patagonian toothfish (*Dissostichus eleginoides*) © CSIRO Marine Research

Mackerel icefish lives in shallow waters from 100 to 350 m, it is short-lived (<6 years) and there are *separate stocks supporting fisheries around South Georgia, Kerguelen and Heard islands* (Constable 2002:75). Mackerel icefish fisheries became a target of Soviet fleets when abundance of Marbled rockcod declined in the mid-1970s. The fisheries for Mackerel icefish were the only viable finfish fisheries to remain from the notothenid fisheries prior to the establishment of CCAMLR.

Other fisheries

An exploratory pot fishery for crabs (*Lithodidae*) is a very recent development in waters around South Georgia and Shag Rocks. It commenced with fishing by the United States in 1992 and two species have been targeted: *Paralomis spinosissima* and to a lesser extent *P. Formosa* (Kock 1994). Although not currently economically viable, the fishery is limited to sexually mature male crabs and a TAC has been set at 1600 t annually (CCAMLR 2002c). In 2002, a Japanese fishing fleet commenced a commercial crab harvest in waters around of South Georgia and Shag Rocks. In addition, there are large squid fisheries that include *Martialia hyadesi* directly north of the Southern Ocean, such as those on the Patagonian and New Zealand shelves and around South Georgia (CCAMLR 2002c; Kock 1994). However, only an exploratory fishery for squid exists at present and no fishing for this species was reported for 2001/02.

3 Management of the Southern Ocean resources

3.1 Antarctic Treaty System (ATS)

Until the Antarctic Treaty came into force in 1961, the IWC was the only international body endeavouring to manage the exploitation of Southern Ocean marine species. Formal negotiations among national governments with an interest in Antarctic affairs in the late 1950s culminated in the 1959 Washington Conference, convened by the United States. The Antarctic Treaty was adopted at this Conference by the seven

Antarctic territorial claimants (Australia, Argentina, Chile, France, New Zealand, Norway, United Kingdom) and five other states (Belgium, Japan, South Africa, United States, USSR).

While the Antarctic Treaty was initially designed to resolve tensions over sovereignty, the freedom of scientific research and the potential militarization of the continent during the Cold War, the Antarctic Treaty Consultative Parties (ATCPs) promptly directed their attention to protecting the Antarctic environment and developed the Antarctic Treaty System (Rothwell 1998). In 1964, the Agreed Measures for the Conservation of Antarctic Fauna and Flora were adopted which was followed in 1972 by the Convention on the Conservation of Antarctic Seals (CCAS).

During the 1980s there was considerable debate among the ATCPs over the need for an Antarctic minerals regime. The 1988 Convention on the Regulation of Antarctic Mineral Resource Activities (CRAMRA) was eventually adopted; however, it was abandoned in 1991 when the need to develop more extensive conservation measures for the Antarctic environment became evident. The Protocol on Environmental Protection on the Antarctic Treaty (the Madrid Protocol) was negotiated in October 1991 and entered into force in January 1998 after being ratified by all of the current 26 ATCPs. According to Rothwell (1998:5), the Antarctic Treaty System has *increasingly given greater attention to the protection of the Antarctic and Southern Ocean environment* particularly with regard to resource management (Plate 3.1).

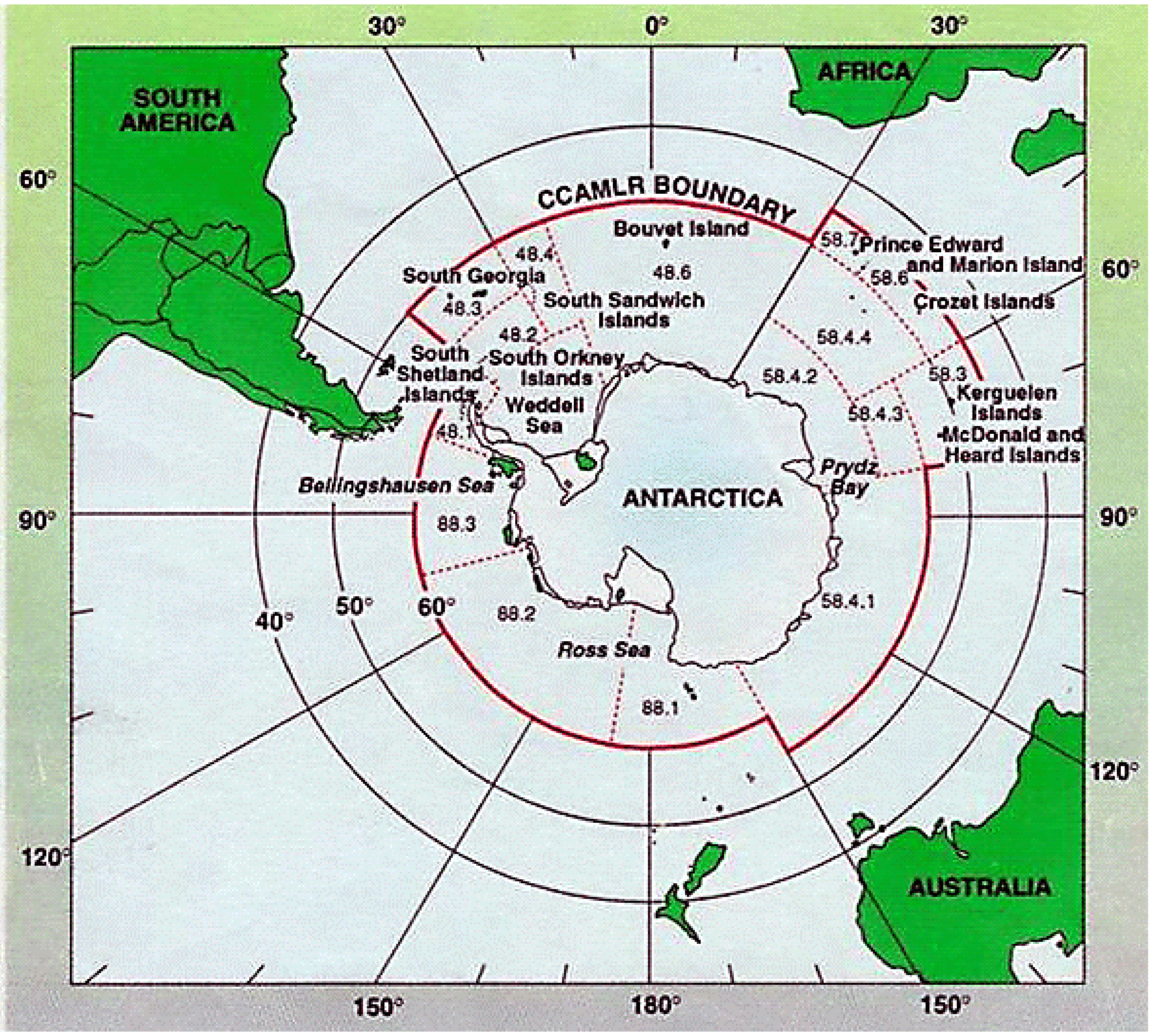
Plate 3.1: Antarctica © Ben Galbraith

3.2 Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR)

For the remaining marine species in the Southern Ocean, and in response to fears of overfishing (especially krill stocks given that krill forms a pivotal link in the Antarctic marine food chain), the 1982 CCAMLR was developed as a consequence of recommendations made initially at the Antarctic Treaty Consultative Meetings VIII and IX in 1975 and 1977 respectively. The Convention was negotiated to ensure the protection of the marine ecosystem and it is considered innovative – being the first to take an ecosystem approach to fisheries management and a precautionary approach (Constable 2002; Constable *et al.* 2000).

The CCAMLR Convention Area extends *to ... Antarctic marine living resources of the area south of 60º South latitude and to the Antarctic marine living resources of the area between that latitude and the Antarctic Convergence which form part of the marine ecosystem* (CCAMLR, Article I(1)) (Figure 3.1). However, CCAMLR does not extend to all activities in the area and only applies to Antarctic marine living resources defined as *the populations of finfish, molluscs, crustaceans and all other species of living organisms, including birds found south of the Antarctic Convergence* (CCAMLR, Article I(2)).

Figure 3.1: Boundaries of the CCAMLR statistical reporting areas in the Southern Ocean.



The CCAMLR Area is divided into statistical areas, sub-areas and divisions, internationally agreed and recognised by the Food and Agriculture Organisation (FAO) of the United Nations which is responsible for collecting and publishing world fishery statistics (CCAMLR 2002a). The three statistical areas are: Area 48 (Atlantic Ocean sector), Area 58 (Indian Ocean sector) and Area 88 (Pacific Ocean sector). The areas are divided to enable the reporting of fisheries data for individual stocks; and to make the imposition of management measures on a stock-by-stock basis possible.

3.3 CCAMLR Commission

The CCAMLR Commission manages fishing activities. The Commission comprises 24 CCAMLR member governments (or State Parties) including Australia, Belgium, Brazil, Chile, European Union, France, Germany, India, Italy, Japan, South Korea, New Zealand, Namibia, Norway, Poland, Russia, South Africa, Spain, Sweden, Ukraine, United Kingdom, United States and Uruguay. Seven states have ratified CCAMLR but have not chosen to become Commission members including Bulgaria, Canada, Finland, Greece, the Netherlands, Peru and Vanuatu. As CCAMLR is an open convention any national government is welcome to participate in the CCAMLR Commission providing it displays serious interest in the Southern Ocean – those *engaged in research or harvesting activities in relation to the marine living resources* (CCAMLR, Article VII(2)(b)).

The CCAMLR Commission headquarters are located in Hobart, Tasmania, Australia. Representatives from member governments meet annually in Hobart to decide policy by consensus decision-making and sovereignty norms, such that each member has a veto. The CCAMLR logo is illustrated in Figure 3.2.

Figure 3.2: CCAMLR logo © CCAMLR

CCAMLR is both a harvesting and conservation regime where harvesting is managed by setting conservation measures in accordance with the sustainable exploitation of resources (or 'rational use') and precautionary principles listed in CCAMLR, Article II. Article II(3) is unique among fisheries agreements requiring that conservation measures are based on consideration of fishery impacts on the entire ecosystem rather than each harvested species. This ecosystem approach aims to ensure that the impacts of a fishery on its predators and other dependent species are considered when fishery decisions are made. It takes into account the needs of fishing operators and the non-human components of the Southern Ocean ecosystems where human harvesters are treated as predators.

The conservation measures adopted by the CCAMLR Commission are based on advice from the Working Group for Fish Stock Assessment (WG-FSA) and the Scientific Advisory Committee (SC-CCAMLR) and its subgroups that also meet annually to recommend quotas, established from statistical sub-areas in the CCAMLR Area for which TACs are set, and adopt conservation measures that member governments implement under their national laws. On occasion, *ad hoc* Working Groups have also been created to deal with specific matters.

3.4 CCAMLR managed fisheries

Nine finfish fisheries, including two exploratory fisheries, were conducted under CCAMLR conservation measures in force during the 2001/02 fishing season. These included Patagonian toothfish fisheries in sub-areas 88.1 and 88.2. Other Patagonian toothfish fisheries occurred in the 200-mile Exclusive Economic Zones (EEZs) of South Africa (sub-areas 58.6 and 58.7 – Prince Edward and Marion Islands), France (sub-area 58.6 and Division 58.5.1 – Kerguelen and Crozet Islands) and Australia (58.5.2 – Heard and McDonald Islands) by trawl and longlines. During this season a single Japanese vessel undertook commercial pot fishing for crabs in sub-area 48.3 and the Republic of Korea undertook exploratory fishing for squid in the same area. Fishing for krill was undertaken by Japan, Republic of Korea, Poland, Ukraine and the United States. CCAMLR fisheries and the TACs set by the CCAMLR Commission are for the 2002/03 season are detailed in Table 3.1.

Table 3.1: CCAMLR fisheries and TAC limits set by the CCAMLR Commission for the 2002/03 season.

CCAMLR Area	Region	Species	TAC (tonnes) 2002/03
48.3	South Georgia	Patagonian toothfish	7810
48.4	South Sandwich Islands	Patagonian toothfish	No assessment
48.6	Bouvet Island	Patagonian toothfish	455t north of 65°S and 445t south of 65°S
58.4.3a	Elan Bank	Patagonian toothfish	250
58.4.3b	BANZARE	Patagonian toothfish	300
58.5.1	Kerguelen Islands	Patagonian toothfish	No assessment
58.5.2	Heard and McDonald Islands	Patagonian toothfish	2879
58.7	Prince Edward Island EEZ	Patagonian toothfish	400
58.7	Prince Edward Island (outside EEZ)	Patagonian toothfish	Prohibited
88.1	Ross Sea	Patagonian toothfish	256t north of 65°S and 350t south of 65°S
88.2	Ross Sea	Patagonian toothfish	375t south of 65°S
48.3	South Georgia	Squid	2500
48.3	South Georgia	Mackerel icefish	2181
58.5.1	Kerguelen Islands	Mackerel icefish	Closed
58.5.2	Heard and McDonald Islands	Mackerel icefish	2980
48.1 & 48.2	Antarctic Peninsula and South Orkney Islands	Other finfish	Closed
48.3	South Georgia	Sub-Antarctic lanternfish	109 000
48.1	South Shetland Islands	Krill	1.008 million
48.2	South Orkney Islands	Krill	1.104 million
48.3	South Georgia	Krill	1.056 million
48.4	South Sandwich Islands	Krill	0.832 million
58.4.2	Prydz Bay	Krill	450 000
58.4.1	Antarctic coastal region	Krill	440 000
48.3	South Georgia	Crab	1600

Source: CCAMLR 2002; AFMA 2002

3.5 Issues for the Antarctic Treaty System and CCAMLR

Rothwell (1998) points out that despite the development of the Antarctic Treaty System, the management of human activities the Southern Ocean raises a number of problems. For example, concerns have been raised that non-State Parties do not always respect CCAMLR's authority. The Southern Ocean also has a mix of maritime and terrestrial areas over which sovereignty is contested, unrecognised, not asserted, or is truly part of the high seas and therefore beyond the limits of coastal state jurisdiction. As a result, Rothwell (1998:5) considers that *these factors make the application and enforcement of international and domestic laws in the Southern Ocean more complex than in any other comparable maritime space*.

In addition, there remain many difficult issues in determining how other legal regimes created under the 1982 United Nations Convention on Law of the Sea (LOSC) and international environmental law are recognised and implemented in relation to CCAMLR (Fallon and Kriwoken *submitted*). These regimes include (i) the 1993 Code of Conduct for Responsible Fisheries; (ii) the 1993 Agreement to Promote Compliance with International Conservation and Management Measures by Fishing Vessels on the High Seas (the Compliance Agreement) (FAO 2002a; 2002b, 2000; Haward *et al.* 1998); and (iii) the 1995 Agreement for the Implementation of the Provisions of LOSC relating to the Conservation and Management of High Seas Straddling Fish Stocks and Highly Migratory Fish Stocks (the Fish Stocks Agreement (UNFSA)) (United Nations 2001).

When consideration is also given to the legitimacy of domestic legal regimes, which seek to give effect to the Antarctic Treaty System or national policy, the legal regime of the Southern Ocean presents complexities that are not encountered elsewhere. By extending the operation of CCAMLR beyond the limits of the Antarctic Treaty so that it has impact upon the potential sovereign rights of claimant States to freely exploit marine resources in adjacent offshore areas, the Convention raises complex sovereignty issues. However, Rothwell (1998:17) considers that, despite the CCAMLR Area *extending to the maritime zones of the sub-Antarctic islands, those States that possess uncontested territorial sovereignty over those islands do not concede the sovereign rights by becoming parties to the Convention* – for example, the EEZs controlled by South Africa, France and Australia. At the same time, CCAMLR also makes allowance for those nation states that do not recognise any territorial claims in Antarctica or the Southern Ocean islands. This bi-focal approach seeks to maintain the status quo as established by the Antarctic Treaty (CCAMLR, Article IV(2)).

Other institutional and political problems have also impeded CCAMLR's success in managing how people use and value marine resources. For example, restrictions surrounding the consensus decision-making structure of the CCAMLR Commission and its ability to impact on the strength of adopted conservation measures emerged in the 1980s. In addition, uncertainty about the Southern Ocean fisheries and lack of data upon which the SC-CCAMLR or the CCAMLR Commission can assess how an ecosystem approach can be best implemented are other problems. Another area of difficulty that emerged early was that the relationship between the CCAMLR

Commission and SC-CCAMLR was not adequately determined. This resulted in tension over *whether the opinions of the SC-CCAMLR* (scientists) *should be accepted as fact* by the CCAMLR Commission (governments) or whether the *Commission remains able makes its own independent judgments* (Rothwell 1998:21).

Over time, the strength and ambit of the CCAMLR conservation measures have been expanded and strengthened. In addition, data collection has improved and there is a greater understanding with respect to Antarctic marine living resource stocks and ecosystem management. Tensions between the SC-CCAMLR and CCAMLR Commission have also been resolved. Despite the difficulties faced by CCAMLR, the ecosystem approach to resource management adopted by this Convention distinguishes it from similar institutions in that it attempts a truly international and collaborative institutional resource management regime.

4 Fishing techniques

Fishers use different techniques to harvest marine species in the Southern Ocean. Finfishing is conducted by trawling and longlining, although some pot fishing for Patagonian toothfish has been tried. Krill is harvested by trawling, pots are used to harvest crabs and squid is harvested using jig lines. Jig fishing for squid has only been conducted on an experimental basis in waters adjacent to South Georgia from 1996/97 (Kock 2001). Fisheries and the harvesting methods used in the CCAMLR Area are detailed in Table 4.1.

Table 4.1: Fisheries in CCAMLR statistical areas 48, 58 and 88.

Fishery	**Species**	**Subarea**	**Division**
Longline	Patagonian toothfish	48.3, 48.4, 48.6, 58.6, 88.1, 88.2	58.4.4, 58.5.1, 58.4.1, 58.4.2, 58.4.3
Trawl	Patagonian toothfish		58.5.2, 58.4.1, 58.4.2, 58.4.3.
	Mackerel icefish	48.3	58.5.2.
	Wilson's icefish		58.4.2.
	Krill	48	58.4.1, 58.4.2.
	Lanternfish		58.5.2, 58.4.1, 58.4.2, 58.4.3.
Pot	Crabs	48.3.	
	Patagonian toothfish	48.3.	
Jig	Squid	48.3	

Fallon (*work in progress*): Adapted from CCAMLR 2002b

4.1 Trawling

Until the mid to late 1980s fishing in the Southern Ocean was entirely a trawl fishery. There are principally two types of trawling – bottom and midwater trawling.

Krill is harvested in midwater using fine-mesh trawl nets. In addition, some finfish is also harvested using midwater trawls such as Patagonian toothfish. Trawl fisheries for Patagonian toothfish were first reported from 1976/77 but were then developed around South America and the Southern Ocean in the mid-1980s (Agnew 2000). Other target species of the trawl fisheries are, or have been, Marbled rockcod, Mackerel icefish, Grey rockcod, Patagonian rockcod, sub-Antarctic lanternfish and

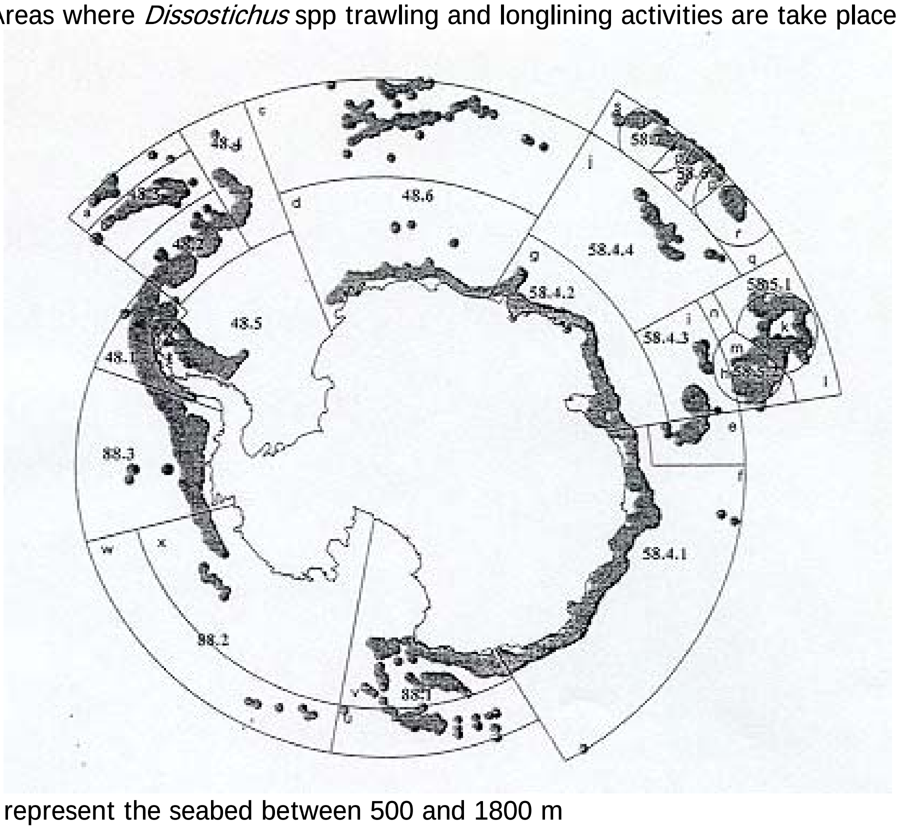
Wilson's icefish (SC-CCAMLR 2002; Kock 1994). Most species have been fished primarily for human consumption, while the small Patagonian rockcod and sub-Antarctic lanternfish have been targeted for fish meal.

However, trawling indiscriminately harvests non-target species or bycatch. Frequent trawl fishing bycatch in the Southern Ocean has included Humped rockcod (*Gobionotothen gibberifrons*), various icefish species and skates (*Raja Georgiana* and *Bathyraja spp.*). For example, krill trawling can sometimes include substantial bycatch of larvae and juvenile fish, such as Mackerel icefish on the South Georgia shelf. Bycatch in the bottom trawl fishery near South Georgia and the South Orkney Islands, such as the Humped rockcod and icefish were overexploited by the mid-1980s. In addition, seabirds can collide with, and become entangled in, fish monitor cables and marine mammals have reportedly become entangled in trawl gear.

Bottom trawling also causes environment impact by scraping and ploughing the seabed, which resuspends sediment and destroys benthos (or the marine fauna living in and on the bottom of the ocean). Given the remoteness and depth of the Southern Ocean, the extent of environmental impacts caused by bottom trawling on benthos and fish spawning grounds are unknown (CCAMLR 2002a; Kock 2001). However, the effects are likely to be long-lasting given the fragility of these communities. The CCAMLR Commission has prohibited the use of bottom trawls in some fisheries to minimise the impact of trawling on non-target species and the seabed.

According to CCAMLR (2002d) fishable depth ranges for Patagonian toothfish are 500-1500 m for trawling and 600-1800 m for longlining as detailed in Figure 4.1.

Figure 4.1: Areas where *Dissostichus* spp trawling and longlining activities are take place.



Shaded areas represent the seabed between 500 and 1800 m
Source: CCAMLR 2002d

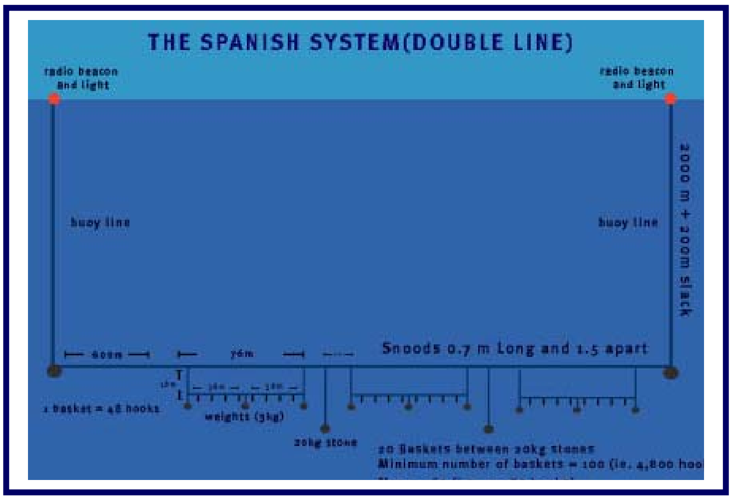
4.2 Longlining

Longline fishing involves setting a mainline (also called groundline or motherline) with many individual baited hooks on branchlines (also called a snood, secondary line, gangion or gangline) (Ashford 2001; Preston *et al.* 1998). Some longliners set lines of over 100 kilometres with more than 20 000 hooks attached, although they vary considerably in length and number of hooks (Birdlife International 2001). The main line can be oriented vertically or horizontally and is laid on the seabed with anchors, buoys, buoy lines and radio beacons at both ends (ISOFISH 2002).

Longlines can be deployed demersally, pelagically or semi-pelagically. The Patagonian toothfish fishery currently uses three types of demersal longline gear (Ashford 2001). Demersal (bottom set) longlining is also called 'ground fishing' because it targets fish that live at, or near, the seabed and this highly efficient fishing technique is the most common method of setting (Bjordal and Løkkeborg 1996). Demeral longlines were introduced in 1985/86 and were in full commercial operation at South Georgia by 1988/89 and around the Kerguelen Islands by 1991/92 (Kock 1994). The development of longlining led to a rapid increase in Patagonian toothfish exploitation during the 1990s, which then progressively had impact on the fisheries around southern South America and the Southern Ocean (CQFE 2002a). This technique entails fishers trailing from ships lines that are armed with thousands of baited hooks that are set at depths ranging from 500-2500 m (AAD 2001b). The lines can be longer than 5000 m and have up to 5000 hooks, and vessels might set and haul up to 40 000 hooks per day.

Demersal longlining generally employs the Spanish and autolining/Mustad methods that may use a wide variety of adaptations depending on local conditions. The Spanish method is labour intensive and it is mainly used by Chilean, Uruguayan and Argentinean fishers (Alexander *et al.* 1997). It employs two parallel lines – a thin mainline that holds the branch lines and hooks and a thicker (hauling or safety) line that is un-weighted and floats above the main line (ISOFISH 2002; Kock 2001). The safety line is heavier than the main line at 15-20mm diameter (Bjordal and Løkkeborg 1996). The fishing line is weighted at 20 m intervals and between each weight are 30 hooks on one-metre long nylon snoods (Figure 4.2). The bait (half frozen fish and/or squid) is manually attached to the hooks (Kock 2001). This technique is used in areas where strong currents and rough sea floors otherwise cause high gear loss. The safety line allows the main line to be retrieved at the next linkage point to the safety line even if it breaks.

Figure 4.2: Demersal longlining generally employing the Spanish method.

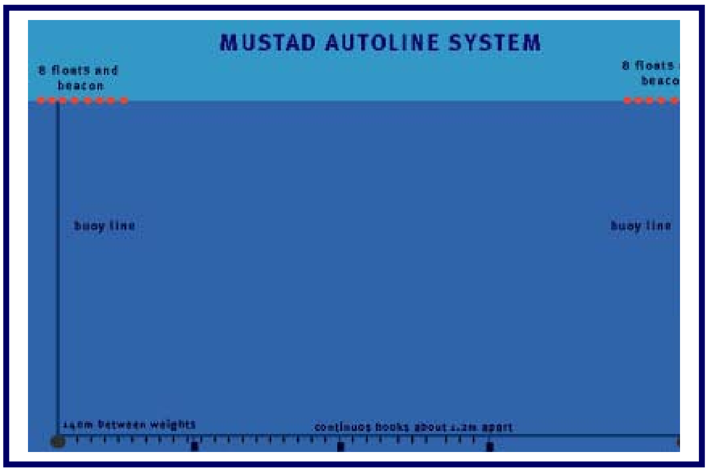


Source: ISOFISH 2002

Many fishing lines can be deployed during a single set. According to ISOFISH (2002), approximately 80 per cent of illegal fishing vessels use the Spanish longlining method, as opposed to the autolining/Mustad method that requires more expensive equipment.

The autolining/Mustad method was developed especially for the Patagonian toothfish fishery and it employs a single longline 70-130 kilometres in length to which are attached baited branchlines up to one metre in length (Figure 4.3). ISOFISH (2002), identifies that the line used is exceptionally thick (in general 11.5 mm diameter) to tolerate the stresses of deep-sea fishing. This system uses automatic baiting where the bait (half frozen fish and/or squid) is attached with 70 to 90 per cent efficiency (Løkkeborg 1999). As a result, this method has the potential to be less labour intensive and most autolining/Mustad-equipped factory vessels can operate with fewer crew members than those using the Spanish system.

Figure 4.3: Demersal longlining generally employing the autolining/Mustad method.



Source: ISOFISH 2002

ISOFISH (2002) also states that a third demersal longlining method is 'envisaged' because it takes the best features from the Spanish and autolining/Mustad systems. The aim is to reduce the size of the mainline to a 7 mm diameter (ISOFISH 2002). This technique would allow for hooks to be baited automatically and increase the maximum breaking strain on lines when they are hauled.

Longlining as a threatening process

Although longlining is an effective fishing technique, it is not highly selective and is one of the greatest threats to seabirds and non-target marine species including finfish and rays. In particular, longlining attracts seabirds by providing food (bait and discarded bycatch and offal). Seabirds are usually caught on baited hooks during the setting procedure and are drowned as the line sinks below the water surface. Every longline hook has the potential to hook incidental catch (or bycatch) and it is estimated that between one and 10 billion longline hooks are set globally each year (Birdlife International 2001). Of the 24 species of albatross, 21 are killed on longlines and at least two are critically endangered (Greenpeace 2000).

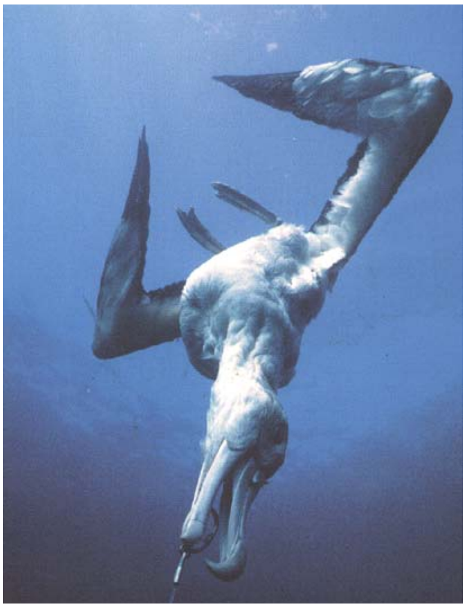


Plate 4.1: Wandering albatross hooked and drowned on a longline © Graham Robertson

According to Kock (2001:46), the *main unresolved problem of fisheries management in the Southern Ocean … is the bycatch of albatrosses and large petrels in longline fisheries*. Southern Ocean wandering albatross (Plate 4.1), black-browed albatrosses and white-chinned petrels appear to have the greatest interaction with fisheries (Croxall and Gales 1998), although other species including grey-headed albatrosses and yellow-nosed albatrosses have been taken (Ryan and Watkins 2000).

Lost and broken lines (from longlines and trawl nets) can also entangle fish, marine mammals, birds and vessels, and discarded bands from bait boxes 'collar' marine mammals. In addition, discharged fish offal can potentially cause population increases in some seabird populations and dependency on this food source.

To reduce bycatch, SC-CCAMLR (2002) and Robertson (2001) recommend making baits less accessible to birds by setting lines deep underwater, using smart hooks, setting lines at night, thawing bait, adding weight to lines to speed up sinking rates, flying streamers on 'tori' lines to scare birds off baits, disguising baits with dye, and holding fish offal on board and/or discarding fish offal discreetly. SC-CCAMLR (2002) noted that night setting of longlines was one of the most effective methods of mitigating albatross incidental mortality in the CCAMLR Area.

Careful post-capture handling and returning live bycatch to the ocean can reduce bycatch. Recovery rates have been found to be higher if bycatch species are cut from lines before they are hauled from the ocean. Alternatively, fisheries can be restricted or closed if fish bycatch targets are exceeded.

5 The case of the Patagonian toothfish

The Patagonian toothfish is a large pelagic predator, belonging to the family *Nototheniidae* (Fallon and Kriwoken *submitted*). It is widely distributed and occurs on the shelf and shelf-slope off islands and banks in the Southern Atlantic, Indian and Pacific Oceans, notably within the influence of the Antarctic Circumpolar Current. It ranges from the slope waters of Chile and Argentina to the sub-Antarctic islands, Macquarie Island just above the Antarctic Convergence and the Indo–Pacific boundary of the Southern Ocean (CCAMLR 2002a). In the South Atlantic, it occurs as far south as the South Sandwich Islands. The closely related species, Antarctic toothfish, occurs further south and is generally restricted to Antarctic waters of 65°S (Agnew 2000) (Plate 5.1).

Plate 5.1: Antarctic toothfish (*Dissostichus mawsoni*) © Ben Galbraith

Both the Patagonian Toothfish and Antarctic toothfish occur in the CCAMLR Area. While Patagonian toothfish is caught both inside and outside the CCAMLR Area, the Antarctic toothfish is found only inside CCAMLR waters (Kock 1992). Up to 96 per cent of Patagonian toothfish stocks are found in waters regulated by CCAMLR or Coastal State jurisdiction that include the EEZs of Argentina, Brazil, Chile and Peru and waters adjacent to sub-Antarctic islands under the sovereignty of Australia, France, New Zealand, South Africa and the United Kingdom (Fallon and Kriwoken *submitted*). Only four per cent of Patagonian toothfish stocks are found outside these areas on the high seas. The catch harvested within the CCAMLR Area or the EEZs of CCAMLR State Parties comprises over 95 per cent of the annual reported catch of these two species.

5.1 Ecology of the Patagonian toothfish

The Patagonian toothfish is grey or brownish grey in colour with darker blotches. It is found in waters warmer than 2°C and lacks anti-freeze, although it has other unusual adaptations to achieve neutral buoyancy, including highly mineralised bones and abundant lipids in their flesh (Cascorbi 2002; Eastman and deVries 1981). They are the largest predatory fish in the mid-waters of the Southern Ocean and have strong muscles to chase down prey (Eastman 1985; Eastman and deVries 1981).

The life history, age, population structure and other measurements required for sustainable management of the Patagonian toothfish in ways that are based in scientific certainty remain largely unknown, underscoring the need for precaution (see Section 9). For example, Patagonian toothfish are difficult to age because otoliths growth rings are difficult to age when members of the species are young. The species typically matures at 8 to 10 years (Kock 2001) and Everson (2001) suggests that they live for at least 40 years, although other commentators suggest they live up to 70 to 80 years (Ecoceanos 2000; ASOC 1998). As a result, age validating techniques are still being investigated, although current scientific research has generally established that this species lives for at least 45 to 50 years (refer to Fallon and Kriwoken *submitted*; Constable 2002; Williams 2001; Constable *et al.* 2000). Like many other deep-water fishes, it seems to put on most of its size in its first 10 years and then grows more slowly.

The reproductive strategy of Patagonian toothfish is characterised by low fecundity and large egg size that indicates a relatively large maternal investment in each egg (Cascorbi 2002; Chikov and Melnikov 1990). Patagonian toothfish eggs and larva are pelagic, free swimming and float near the sea surface to about 500 m. Once the eggs have hatched after about three months, the larva feed on krill and gradually shift to fish. The diet of adults consists of small fish, squid, crabs and prawns (AAD 2002). They mature between approximately 6 to 9 years of age (CCAMLR 2002a; Kock 1992), and in the Atlantic sector of the Southern Ocean, this species spawn over the continental shelf from June to September in water 2200-4400 m deep (Evseenko *et al.* 1998) (Table 1).

Whales and elephant seals eat Patagonian toothfish but the extent of this is unknown, although this species of toothfish is usually too large to be eaten by other predators.

5.2 Uncertainty in assessing Patagonian toothfish stocks

Little is known about the population structure for Patagonian toothfish, how many stocks there are in the CCAMLR Area, or whether just one stock (a ‘straddling stock’) is fished both inside the CCAMLR Area and outside it on the high seas (CQFE 2002b). For example, it is not known if stocks harvested around Shag Rocks and South Georgia inside the CCAMLR Area are a straddling stock that transit neighbouring areas such as the Patagonian Slope (CCAMLR 2002a).

Most current techniques for assessing stocks used by scientists and the CCAMLR Commission rely on identifying isolated populations, particularly those found around South Georgia, with neither immigration nor migration. However, although some research suggests that there appear to be population boundaries, particularly between the southern South America-Scotia Arc region and the islands of the Southern Indian Ocean, it is not known if fish populations are isolated, whether migratory populations transit through areas where resident populations live or if recruitment occurs between populations (CQFE 2002b). Therefore, it is important to accurately establish age data for Patagonian toothfish and determine how they move in time and space if TACs are to be set at a sustainable level for each fishery.

5.3 Commercial exploitation of Patagonian toothfish

Patagonian toothfish was originally caught as a minor bycatch species in the mixed bottom-trawl fisheries targeting Marbled and Grey rockcod cod around South Georgia, Shag Rocks and Kerguelen Islands (Constable 2002). Notwithstanding historical indigenous fishing and a substantial toothfish fishery operating since the mid-1970s off the Chilean coast, large-scale Soviet fishing fleets (later Ukrainian) discovered commercial quantities of Patagonian toothfish in 1985 off the Kerguelen Islands (Fallon and Kriwoken *submitted*; CCAMLR 2002a). It then became a favoured species after the collapse of other over-exploited white-fleshed species, such as Orange Roughy (*Hoplostethus atlanticus*) and black cod (*Anoplopoma fimbria*).

The introduction of longlining in 1985/86 around South Georgia (Kock 2001) resulted in exploitation of larger, mature and older fish from areas inaccessible to trawlers and a substantial fishery began when Spanish operators discovered commercial toothfish stocks off southern Chile in the Pacific Ocean in the late 1980s (Fallon and Kriwoken *submitted*). The development of longlining led to a rapid increase in harvesting during the early 1990s and the fishery expanded to the southwest Atlantic Ocean off Argentina and the Falklands in 1994 (AFMA 2001). Since 1996/97, longlining for Patagonian toothfish has expanded rapidly eastwards into the slope waters of previously unfished islands, banks and seamounts in the Indian and Pacific Ocean sectors of the Southern Ocean including the islands of South Georgia, Prince Edward, Marion, Crozet, Kerguelen, Heard and Macquarie (CCAMLR 2002a; Agnew 2000). Since 1996/97, the Antarctic toothfish has also become the target of a number of new and exploratory fisheries.

In the 1999/00 season, approximately 13 689 t were caught in waters managed by the CCAMLR Commission (Lack and Sant 2001). In the 2000/01 season the CCAMLR Area the catch declined to 13 725 t and in 2001/02 it declined further to 12 817 t (SC-CCAMLR 2002). The main governments whose fishers are legally harvesting Patagonian toothfish are Chile, Argentina, France, Australia, United Kingdom and South Africa and they supplied over 70 per cent of the legal market in 2000 (TRAFFIC 2001c).

6 Pressures on Patagonian toothfish fisheries

6.1 Illegal, unreported and unregulated fishing

The low fecundity of Patagonian toothfish, its long life span of at least 45 years, late sexual maturity and preference for near land habitats, combine to make this species vulnerable to over-fishing (Williams 2001; Agnew 2000). In addition, given the quality of Patagonian toothfish and demand for white fleshed fish generally, market acceptance influenced by declining supply of other species has resulted in increasing pressure on Patagonian toothfish fisheries and the viability of supply being questioned (Fallon and Kriwoken *submitted*; Dodds 2000). This pressure has arisen largely from illegal, unreported and unregulated (IUU) fishing that undermines species management by governments and the CCAMLR Commission (Constable 2002; ASOC 2002a; FAO 2001a). One such fishing fleet reportedly involved in IUU fishing operations by ISOFISH (1998b) is illustrated below (Plate 6.1). Lack and Sant (2001:1) also attribute the proliferation of IUU fishing to *the remoteness of the main fishing grounds and the resultant difficulties and high costs associated with effective surveillance and the relatively low risk of being detected*.

Plate 6.1: Three of the four Glacial longliners moored together, Port Loius © ISOFISH

According to CCAMLR (2002c), toothfish show signs of being overfished in many fishing zones within the CCAMLR Area, particularly around Marion, Prince Edward and Crozet islands, and the Ob and Lena Banks regions. In addition, toothfish is under threat of being overfished in the EEZs around Kerguelen and Heard islands if IUU fishing is not controlled (Fallon and Kriwoken *submitted*; CCAMLR 2002c) and there is anecdotal evidence of IUU fishing pressure in the EEZs of Chile, Argentina and Peru (Exel pers. comm. 2002). In January 2002, IUU vessels were sighted fishing in Antarctic waters south of 60ºS (Stone 2002b). Those nations identified as being, or having been involved in IUU fishing operations for Patagonian toothfish or the landing of IUU catches are listed in Table 6.1.

Table 6.1: Identified past or current involvement in IUU fishing or landing operations.

Identified involvement in the IUU fishing industry	CCAMLR Member
Argentina	✓
Belize	
Chile	✓
China	
Denmark	
Indonesia	
Mauritius	
Namibia	✓
Norway	✓
Panama	
Sao Tome & Principe	
Seychelles	
South Africa	✓
Spain	✓
United Kingdom	✓
Uruguay	✓
Vanuatu	

Adapted from: Austral Fisheries Pty Ltd 2002; Masters 2002; Lack and Sant 2001; ISOFISH 1999a, 1998a, 1998b

Although there is debate over the accuracy of different estimates of IUU fishing, it is agreed by the CCAMLR Commission, national governments, fishers and non-government organisations (NGOs) that illegal fishing continues to undermine the biological sustainability of Patagonian toothfish (Fallon and Kriwoken *submitted*). Kock (2001) identifies that the problem of IUU fishing is fourfold where (i) catches do not provide fisheries data to perform biological and economic assessments in order to adopt sustainable harvest levels; (ii) IUU fishing leads to excessive catches and disregards any fishery restrictions in terms of catch levels or bycatch limits; (iii) dependant or associated species, such as albatrosses and petrels are adversely affected; and (iv) opportunities and income for legal fishers are removed and incentives for these fishers to invest in adequate monitoring, surveillance and control are undermined.

In 1997 catch landings peaked, with Dodds (2000) and Perry (1998) estimating that catches were in excess of 100 000 t and valued at more than $AUD500 million with Japan, the US and increasingly Asia being the largest consumers. According to CCAMLR (2002a), in the 1996/97 season, *estimated catches from unregulated and illegal fishing exceeded those from regulated fishing by a factor of five or more*. Other estimates put IUU fishing in the late 1990s at three times the legal quota (Lack and Sant 2001).

Trade estimates of IUU toothfish catches are generally consistent with the CCAMLR Commission's own, and they indicate a significant drop in IUU catch from 1998 to 2000 to between 17 and 25 per cent of the total catch (TRAFFIC 2001c, 2001d; Lack and Sant 2001) (Table 6.2). However, this range is criticised as IUU toothfish landings may be traded under many names and it is unclear if the figures relate to product weight or green weight.

Table 6.2: Total CCAMLR estimated catch (tonnes) of Patagonian toothfish by regulated and IUU operations 1996/97 – 2001/02.

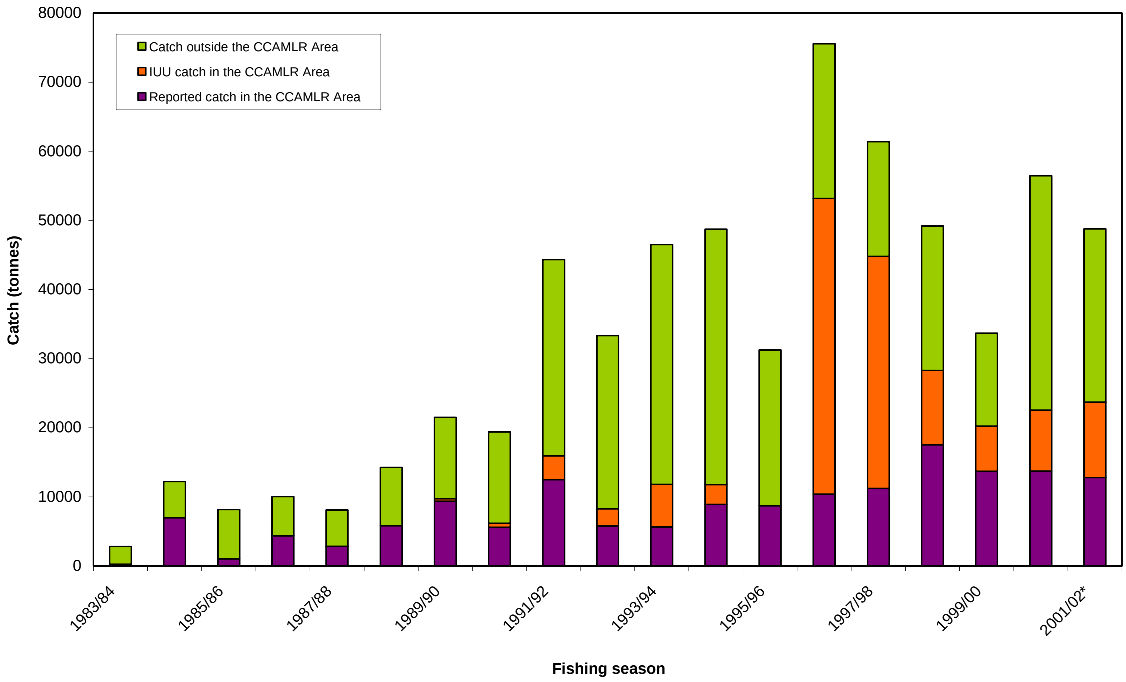
Reported and estimated catch	1996/97	1997/98	1998/99	1999/00	2000/01	2001/02*
Reported legal catch, CCAMLR Area	10 371	11 170	17 278	13 689	13 725	12 817
Estimated legal catch of Patagonian toothfish in EEZs, outside CCAMLR Area	22 365	16 698	20 041	11 553	14 619	10 395
Estimated IUU catch, CCAMLR Area	52 000	22 415	6413	6546	8802	10 898
Total estimated catch, CCAMLR Area	62 371	33 585	23 691	20 235	22 527	23 685
Estimated landings of IUU caught Patagonian toothfish, all areas	68 234	26 829	16 636	8418	N/A	N/A
Total estimated catch, all areas	100 970	54 697	53 955	33 660	56 445	48 769

*Based on available data from the CCAMLR Commission Secretariat on 7 October 2002
Source: Fallon and Kriwoken (*submitted*) – Adapted from Sant & Lack 2001; CCAMLR, 2002c, 2000; WG-FSA 2002, 2000, 1999, 1998

Processed product weights are expressed as 'whole fish' or 'green weight'. Green weight is the standard scientific unit and it refers to total live fish weight. Basic product weight is fish that is headed and gutted before transport and product weight refers to processed fish that is ready for the domestic market.

In the 2001/02 season the estimated unreported catch of Patagonian toothfish in the CCAMLR Area was 10 898 t or 46 per cent of the total catch, as compared with 8 802 t in the 2000/01 season or 39 per cent of the total catch (WG-IMAG 2002). When the 25 054 t of Patagonian toothfish reported as caught outside the CCAMLR Area are included in the catch, the total global harvest in the 2001/02 season is estimated at 48 769 t, in contrast to 56 445 t during the previous 2000/01 season (WG-IMAG 2002) (Figure 6.1).

Figure 6.1: Estimated catches of *Dissostichus* spp (mostly Patagonian toothfish) 1983/84 - 2001/02.



*Note, estimated data only that provides a general indication of *Dissostichus* spp catches
Catch outside the CCAMLR area includes estimated EEZ catch plus estimated high seas catch
Fallon (*work in progress*): Adapted from CCAMLR 2002c; 2002d; Lack and Sant 2001; Agnew 2000

Reports of large catches of Patagonian toothfish taken outside the CCAMLR Area in the FAO Statistical Areas 51 and 57 (approximately four per cent of Patagonian toothfish grounds) lack credibility according to the WG-IMAG (2002). There was agreement at the twenty-first CCAMLR Commission meeting in Hobart in 2002 that catches from Area 51 and 57 were IUU removals and were most likely to have come from within the Indian Ocean sector of the CCAMLR Area (CCAMLR 2002c). The large catches reportedly taken from Area 51 and 57 have significant consequences for the assessment of TACs in the CCAMLR Area and for the viability of Patagonian toothfish populations into the future. Because it is unlikely that the catches reported from Area 51 and 57 are possible and they have most likely been taken from within the CCAMLR Area, it is important that the CAMMLR Commission take these catches into consideration when assessing future TACs within the CCAMLR Area.

TRAFFIC (2001b) also considers that a likely explanation for the variations in the estimates of IUU fishing may lie in the shortcomings of the estimates themselves. For example, the CCAMLR Commission acknowledges that it is becoming more difficult to estimate IUU catch because of the increase in trans-shipment at sea together with landings under different species names. Therefore, CCAMLR's IUU estimates catch are regarded to be under-estimates of the true catches.

6.2 Incidental mortality of non-target species

Longlining is a highly efficient and targeted fishing method to harvest Patagonian toothfish. It is also fatal to non-target species including seabirds, skates and rays. The extent of bycatch of non-target species has concerned fishers' managers; scientists and conservationists (Waterhouse 2001; Agnew 2000; Haward *et al.* 1998) because these species may become endangered if mitigation measures are not implemented or remain effective in curbing incidental mortality (Fallon and Kriwoken *submitted*).

A watershed publication in 1991 by Nigel Brothers was the first to indicate that an estimated 44 000 albatrosses were taken annually as bycatch in longline fishing operations in the Southern Ocean. Since that time, incidental seabird mortality may be as high as 100 000 seabird deaths per year for those breeding on the sub-Antarctic islands in the Southern Ocean (ISOFISH 2002; Birdlife International 2002). The *ad hoc* CCAMLR Working Group on Incidental Mortality Arising from Fishing (WG-IMAG) estimates that seabird bycatch due to IUU fishing in the CCAMLR Area since 1996 is between 278 400 to 700 200 birds (WG-IMAG 2002). Potential seabird bycatch is detailed in Table 6.3.

Table 6.3: Estimated total potential seabird bycatch associated with IUU fishing for Patagonian toothfish in the CCAMLR Area.

	Year	Lower-level estimate*		Higher-level estimate*	
Total	1996	37 100	49 700	67 100	90 000
	1997	59 700	79 800	107 700	144 600
	1998	32 700	43 700	60 700	81 600
	1999	32 400	43 400	64 500	86 600
	2000	34 600	42 200	71 500	96 000
	2001	43 400	58 000	80 500	108 000
	2002	38 500	51 500	69 600	93 400
Overall total		278 400	372 300	521 600	700 200

*Rounded to nearest thousand
Source: WG-IMAG 2002

Bycatch has reduced substantially since 1997 in the legal fishery; however, over the past six years since that time as many as 144 000 albatross, 24 000 giant petrels and 378 000 white-chinned petrels may have been killed as a result of IUU fishing (WG-IMAG 2002). It is noteworthy that most albatross are from populations classified as critically endangered by the World Conservation Union.

The conservation measures (Conservation Measure 1213/XIX) put in place by the CCAMLR Commission in 1991 to minimise seabird mortality from longline fishing have been successfully adopted for *licensed* fishing operations in the regulated fishery (including setting lines deep underwater or at night, thawing bait, adding weight to lines to speed up sinking rates, or flying streamers on tori lines to scare birds off baits). However, illegal fishers do not use these methods, and their operations threaten seabirds. We acknowledge that the legal longline fleet at South Georgia caught a small number of seabirds while harvesting Patagonian toothfish in 2001

(Exel pers. comm. 2002). However, the illegal fleet, which uses no longline mitigation measures, caught many thousands of birds over the same period (IMAG 2002). This example illustrates that the problem is not longline fishing *per se*, but rather the *lack of mitigation measures* being used by illegal fishers who work with longlines (Fallon and Kriwoken *submitted*).

7 Trade in Patagonian toothfish

7.1 Patagonian toothfish markets

Restaurant quality white flesh, few bones, firm musculature and oil-rich flesh have made the Patagonian toothfish a popular eating species (Fallon and Kriwoken *submitted*; Cascorbi 2002; Lack and Sant 2001). Indeed, such is the demand that over 90 per cent of toothfish products enter into international trade (TRAFFIC and WWF 2002).

This species is highly valued in restaurants in the United States and Japan, which imported an estimated 90 per cent or more of Patagonian toothfish available through worldwide trade in 2000 (TRAFFIC 2001c). Canada and the Economic Union now also import toothfish (Lack and Sant 2001). Increasingly, too, East Asia is a growing market (Austral Fisheries Pty Ltd 2002; Masters 2002), and in the main markets prices have been as high as $USD10 per kilo for headed, gutted and tailed fish. TRAFFIC and WWF (2002) note that Patagonian toothfish sells for up to $USD35 per kilo at retail outlets, Montgomery (2002:28) reports that top-quality toothfish *bring up to $AUD100 per kilogram in Japan for sashimi* and Perry (1998) states that a single fish can fetch up to $AUD1500.

Patagonian toothfish market information

Market names: Mero, Chilean Sea Bass, Black Hake, Bacalao de profundidad and Butterfish.

Seasonal availability: available all year round. Actual fishing is concentrated in May to July during the Antarctic winter.

Product forms: sold as frozen whole fish (headed and gutted), frozen fillets and fresh fillets.

Analysis of market data for Patagonian toothfish prior to 1998 is problematic because of inconsistencies arising largely from the absence of harmonized trade codes (TRAFFIC 2001a). Since 1998, the number of national governments that record trade data according to the Harmonized Commodity Description and Coding System (HCDCS) has gradually increased; however, the data have yet to provide analysts with a comprehensive overview of world markets.

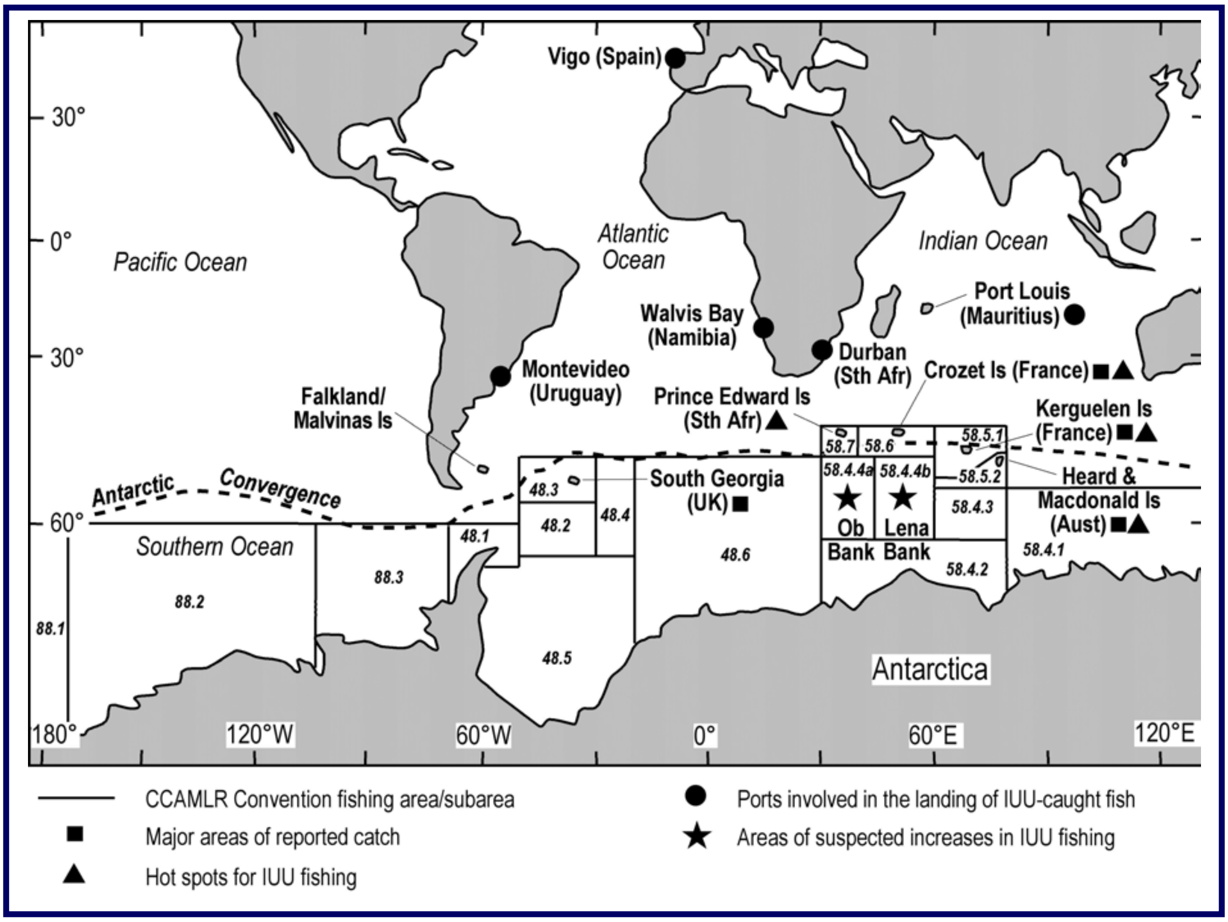
Among the major trading nations, trade data on ‘frozen fillets’ and ‘frozen other’ are available for Australia, Canada, Chile, European Union member states, Japan and the

United States (TRAFFIC 2001a). ‘Frozen other’ includes the headed and gutted product together with all other forms apart from fillets. Canada and the USA also identify a category of ‘fresh fish’.

7.2 Illegal trade of Patagonian toothfish

TRAFFIC asserts that 11 nations are involved in illegal trade of Patagonian toothfish (Cascorbi 2002; Lack and Sant 2001). Until 2001, IUU fishing was apparently dominated by Spanish-owned fishing companies that employ vessels registered through Flag of Convenience States such as Panama, Vanuatu and Belize (TRAFFIC 2001b). In addition, the Norwegian and Chilean fishing industries are alleged to have been heavily involved in the illegal trade (ISOFISH 1998a, 1999a). The ports of Durban (South Africa), Montevideo (Uruguay), Port Louis (Mauritius), Vigo (Spain) and Walvis Bay (Namibia) have allegedly received IUU catch in recent years (TRAFFIC 2001b; ISOFISH 1998b). Apart from Mauritius, all are members of, or acceding states to, CCAMLR. The principal Patagonian toothfish fishing grounds in the Southern Ocean and the ports involved in the landing of IUU caught fish are detailed in Figure 7.1.

Figure 7.1: Southern Ocean and principal Patagonian toothfish fishing grounds.



Source: Fallon and Kriwoken (*submitted*) – Adapted from Trade Records Analysis of Flora and Fauna in International Commerce (TRAFFIC Oceania)

More recently, Chinese and Indonesian interests have apparently entered the illegal industry and trade in Patagonian toothfish may have become the focus of trans-national crime (Masters 2002). Austral Fisheries Pty Ltd (2002:2) asserts that Chinese and Indonesian illegal operators *disguise the origin of their fish and fish products … through … processing and distribution operations and trading operations … recycled fish products are then sold through legitimate trading relationships.* In addition, the incidence of trans-shipment at sea is increasing, and on the high seas Patagonian toothfish catches are being transferred from vessels of one nation to another (Cascorbi 2002).

7.3 Responsibility of consumers

Given that Patagonian toothfish is sold under a number of different names, consumers (and particularly those in the northern hemisphere) may not identify their purchase with a vulnerable/endangered species sometimes caught illegally or in unregulated fashion. Given, too, that people from these nations consume the majority of Patagonian toothfish products, they have opportunities to curb the illegal fishing that threatens the sustainability of this species by affecting demand such that it becomes unattractive to harvest.

The United States Government has taken the lead in curbing illegal trade within its borders. In May 2000, for example, the National Marine Fisheries Service (NMFS) adopted new rules on the import of Patagonian toothfish into the United States (*SeaWeb* 2000). These rules require that, within 24 hours of delivery to United States traders' importers send catch documents to the Service verifying that fish were caught outside the CCAMLR Area, or that they were harvested within the Area *and* in conformity with CCAMLR conservation measures (Agnew 2000).

The United States Government strengthened this requirement at the twenty-first CCAMLR Commission meeting in Hobart in 2000, and announced changes to its domestic Import/Export Control Program that will effectively prohibit the import of toothfish from December 2002 caught outside the CCAMLR Area in the unregulated waters of FAO Statistical Areas 51 and 57 (Fallon and Kriwoken *submitted*). Despite such advances, the commitment among other nations to continue to import Patagonian toothfish will need to be addressed if illegal trade is to be mitigated.

NGOs and chefs in the United Stares have also launched a campaign entitled *Take a Pass on Chilean Seabass*. According to Brian Handfwerk from National Geographic (2002) more than 700 chefs (reportedly worldwide but most likely to be mainly in the United States) have agreed to stop serving the fish until stocks recover. Campaign organisers hope to encourage consumers to buoycott Patagonian toothfish at local markets. However, some commentators warn that this strategy will harm legitimate fishers because illegally caught fish will continue to be sold to other markets.

The staff of various NGOs have also suggested an international moratorium temporarily banning all fishing and international trade in Patagonian toothfish (Greenpeace 2000; ASOC 1998). They argue that the legal fishery provides a shadow under which illegal fishers operate. By removing the Patagonian toothfish from the world market, IUU fishing will be revealed because products that make their way onto world markets will be illicit (ECO 2001). The campaigners maintain that the moratorium should not be lifted until:

- IUU fishing has been brought under control;
- stocks assessments are conducted for each fishery that includes stock structure, spawning grounds and recruitment;
- a trade system is introduced that provides independent verification on the source of legal and illegal catches; and
- incidental seabird mortality is severely constrained or eliminated, and fish bycatch is brought under control.

8 International actors of influence

International actors include (i) international bodies and nation states who have an necessary preoccupation with sovereignty and national security, (ii) the owners of major fishing companies exploiting Southern Ocean resources and related economic interest groups, (iii) scientists, (iv) NGO staff, volunteers and members, and (v) the residents of communities who either seek to conserve Patagonian toothfish stocks or wish to consume the fish.

8.1 CCAMLR State Parties

CCAMLR State Parties are taking steps to respond to the problem of IUU fishing but each step is slow, restricted and characterised by significant restraints on the control of these activities. Some constraints are financial, such as the costs of monitoring and enforcement. Others are conceptual; related more closely to restrictions in law and policy. For example, the adoption of a mandatory vessel monitoring system (VMS) that involves installing satellite-tracking devices on board fishing vessels to monitor fishing activities, has been criticised by some CCAMLR members on the grounds that it unacceptably interferes with members' rights on the high seas.

8.2 Commercial fishers

Commercial fishers may operate legally or illegally (Fallon and Kriwoken *submitted*). They may pursue their interests through CCAMLR State Parties by influencing the position that those parties take or they may take part in national delegations to the CCAMLR Commission. This influence has positive and negative consequences. For example, fishers may provide substantial positive outcomes to this industry by adopting sustainable fishing practises, providing surveillance in distant waters or conducting research into IUU fishing operations. In 2002, Austral Fisheries Pty Ltd from Australia supported the unsuccessful Australian proposal to list Patagonian and Antarctic toothfish on schedule II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). A group of commercial fishers from Australia, New Zealand and South Africa indicated their support, both in principal and financially, for a centralized VMS at the twenty-first CCAMLR Commission meeting in Hobart in 2002. Conversely, fishers may seek to advance their own interests and persuade their governments that supporting CCAMLR conservation initiatives is not in the national interest.

8.3 Non-government organisations

NGOs emerged in the 1980s as international actors of influence in Antarctic forums (Fallon and Kriwoken *submitted*). The power of these groups lies in their ability to influence governments directly and indirectly through the electorate. They have no enforcement authority except that which may be given them under domestic legislation. As a result, they may monitor compliance but can only report violations and urge action on governments.

With respect to Southern Ocean affairs, much of the NGO effort has been directed through the internationally based Antarctic and Southern Ocean Coalition (ASOC). ASOC was formed in 1977 and comprises over 250 conservation groups (including Friends of the Earth, Greenpeace and WWF) from more than 50 countries (Boyd 2002). Its strength stems from this alliance, a singularity of purpose and an ability to draw upon many contacts including those in governments (Fallon and Kriwoken *submitted*). Through the Antarctica Project, the ASOC secured observer status at CCAMLR Commission meetings in 1988 (CCAMLR 1988).

Linked to domestic environmental groups, ASOC has successfully coordinated domestic and international lobbying activities to pressure national governments (Bush 2002). In many cases, ASOC's international delegates to the CCAMLR Commission have been well briefed and, with the support of a public constituency, have maintained their independence from official and commercial pressure. According to Bush (2002:130), *how much longer states continue to be receptive will depend on the extent that the environmental organizations are challenged by commercial actors and how important the states themselves remain as actors of influence in Antarctic affairs*.

The International Southern Oceans Longline Fisheries Information Clearing House (ISOFISH), is another NGO based in Australia (Figure 8.1). It was established in 1997 with a specific mandate to stop IUU fishing.

Figure 8.1: ISOFISH logo © ISOFISH

The ISOFISH coalition of NGO representatives and commercial fishers found measures to deal with the limitations of governmental power and add value to government efforts to curb IUU fishing. This strategy is important, given that governments have a limited capacity to act against illegal poaching because national laws constrain their actions (Fallon and Kriwoken *submitted*). Partly as a result of pressure applied by ISOFISH, CCAMLR State Parties and various national governments have become more committed to finding solutions to eliminate IUU fishing.

8.4 International scientific community

The international scientific community has also been an influential actor in Southern Ocean affairs. For example, the Antarctic Treaty and CCAMLR negotiations have been heavily influenced by the activities and contributions of the Scientific Committee on Antarctic Research (SCAR) and its various programs.

Initially, the International Council of Scientific Unions (ICSU) was established in 1957 with the task to continue co-operative scientific research in Antarctica during the International Geophysical Year (IGY) of 1957-58. Twelve nations were involved in Antarctica during that time and agreed that political and legal differences should be set aside in the interests of carrying out scientific work in close and peaceful cooperation (Australia 1993). The success of the IGY led to the governments of these twelve nations to establish the Antarctic Treaty in 1959.

Until 1961, SCAR was established as a committee of the ICSU but it was then re-named to reflect its emerging influence. The First International Conference on Living Resources of the Southern Ocean was held at Woods Hole, Masssachusetts in 1976 and recommendations from this meeting resulted in the 10-year Biological Investigation of Antarctic Systems and Stocks (BIOMASS) that focused on krill stocks. Along with the Scientific Committee on Oceanographic Research (SCOR), the Intergovernmental Oceanographic Commission (IOC) and International Association of Biological Oceanography (IABO), SCAR contributed to the development of CCAMLR. However, once CCAMLR was negotiated and its SC-CCAMLR and working groups were established SCAR's influence declined.

8.5 Interests of international actors

Bush (2002:129) considers *that the Antarctic may well attract the attention of large corporations over which, by virtue of economic globalization, individual states may have only limited control*. In this context, large scale IUU fishing in the Southern Ocean is a manifestation of the power of private commercial actors. These operators are prepared to risk assets for high returns.

Open access resources

Whether operating legally or illegally, fishers operate in the modern globalised economy (Fallon *work in progress*). Novel dimensions introduced by economic globalization are twofold: vast accumulations of capital and a monetary system that allows this to be moved around the globe with few restrictions. Although the Antarctic has possibly attracted little of this capital, IUU fishing is increasingly becoming identified as a large-scale transnational activity where operators are increasingly from East Asia (Masters 2002; Austral Fisheries Pty Ltd 2002).

Broadly there are two models of political organisation pursuing economic interests: those with state territorial control or those outside territorial control (Bush 2002). Claiming territory is at the heart of the concept of the nation state and the traditional method of states asserting control over environmental resources (Wapner 1998; Kaimieniecki and Scully Granzeier 1998). In the Antarctic, explorers and commercial interests urged their governments to assert sovereignty as a means to secure rights to resource exploitation.

Alternatively, there is the open access model that is exemplified by access to high seas resources. Typically, if access to resources in the high seas is to be restricted particular limits need to be imposed by the state of nationality. Consequently, territorial jurisdiction controls territory whereas national jurisdiction applies to open access.

According to Bush (2002:136), *open access is attractive to states that, themselves or through their nationals, are able to exploit a resource*. The state retains maximum discretion and is not beholden to other states. Private operators too, are likely to find open access regimes attractive because these regimes promise greater freedom. The restrictions imposed on fishers and the fishing industry by some states maybe less restrictive than those imposed by another. Under the open access system, commercial operators dissatisfied with the restrictions of one state may re-arrange their affairs under the national jurisdiction of a less restrictive state. In an extreme form this scenario can lead to the use of Flags of Convenience.

An open access system leaves greater scope for private actors to self-regulate. In the nineteenth century, remoteness and communication technologies now considered slow allowed commercial operators to exploit maritime resources without interference from even their states of nationality. However, if the open access principle is applied to current economic activities in the Southern Ocean, the prospects for sustainable harvesting of resources is poor. This prognosis is exemplified by the case of nineteenth century sealing, twentieth century whaling and more recently, finfishing in the Southern Ocean. Reduced finfish stocks have occurred despite the conservation measures adopted by the CCAMLR Commission.

Consequently, in a highly capitalized Patagonian toothfish fishing industry, it makes commercial sense to seek maximum returns on capital outlays if the resource is likely to be exhausted quickly, and then capital can be invested elsewhere (Fallon *work in* *progress*). Restraint is unlikely to maximize returns as other operators may take the resource, or if fishers delay harvesting the stock additional capital needs to be outlayed in the future to secure the resource.

The open access principle is expressed in CCAMLR as it does not limit any state's access to Southern Ocean resources while the state complies with measures put in place regulating that access (Bush 2002). Conservation measures do not discriminate on the grounds of nationality and regulation relies on national enforcement – principally by controlling the Flag State of the vessel. As a result, open access makes the effectiveness of CCAMLR vulnerable to third party operations (activities of vessels not flagged by a party to the regime). CCAMLR is also vulnerable to the lack of apportionment of TAC among commercial operators or CCAMLR State Parties. Finally, the variation between the CCAMLR State Parties in rigor and procedures of domestic implementation, inspection and enforcement can result in operators taking advantage of weaker regulation measures that may be imposed by some states.

Measures adopted by CCAMLR

The CCAMLR Commission has endeavoured to apply uniform measures to regulate open access fishing activities in the Southern Ocean. In particular, it has developed a number observation and conservation measures in the *Dissostichus* spp. longline fisheries to protect Patagonian and Antarctic toothfish (Table 8.1).

Table 8.1: Development of the main CCAMLR observation and conservation measures in the *Dissostichus* spp. longline fisheries.

Date	CCAMLR information/action	CCAMLR conservation measure (CM)
1985/86	Longline fishery started at South Georgia	
1989/90	First information on the fishery The Soviet Union stated its intention not to increase catch levels around South Georgia	
1990/91	Slight increase of information	CM 24/IX – first introduced catch limits in the Patagonian toothfish (*Dissostichus eleginoides*) longline fishery for the 1990/91 season CM 26/IX – required the reporting of seabird entanglement and mortality in the Patagonian toothfish longline fishery
1991/92	First estimates of seabird mortality	CM 29/X (and later XI; XII; XIII; XIV; XV) – applied mitigating measures in the CCAMLR Area to reduce incidental seabird byctach from 1991 onwards CM 30/X – prohibited the use of net monitor cables in an effort to reduce seabird bycatch from the 1994/95 season
1992/93	Further information on bycatch	CM 29/XI –introduced to reduce seabird bycatch including compulsory observer coverage, use of streamer lines, prohibition of offal discharge and the restriction to night setting of longlines
1993/94	Review incidental mortality information Success of bycatch mitigation measures Observer coverage on longline vessels Publication on how to set longlines correctly South Georgia was designated a 'Special Area of Protection and Scientific Study' for the season	CM 29/XII – aimed to minimise incidental seabird byctach – TAC* of 1300 tonnes at South Georgia CM 63/XV – regulates the use of plastic packaging bands on fishing vessels, it was introduced to reduce the amount of plastic floating in the Southern Ocean, conservation measure aims to protect Antarctic fur seals and it prohibits the use of plastic bands to secure bait boxes from 1995/96 onwards

1994/95	Publication on how to set longlines correctly in CCAMLR Area elsewhere	CM 29/XIII – aims to minimise incidental seabird byctach – TAC* of 2800 tonnes at South Georgia
1995/96	Improvement of scientific data collection to improve fishing efficiency Handbook, *Fish the Sea not the Sky*, was published by CCAMLR in 1996	CM 29/XIV – aims to minimise incidental seabird byctach – TAC* of 4000 tonnes at South Georgia
1996/97	CCAMLR concerned about IUU fishing Development of IUU fishing by CCAMLR Decline of seabird bycatch in the regulated fishery Improved scientific data collection	CM 29/XV – aims to minimise incidental seabird byctach – TAC* of 5000 tonnes at South Georgia and precautionary TACs in all other areas
1997/98	High IUU catches particularly in the Indian Ocean Further decline of seabird bycatch in the regulated fishery Improvement of scientific data collection	CM 29/XVI – aims to minimise incidental seabird byctach – TAC* of 3300 tonnes at South Georgia and precautionary TACs in all other areas
1998/99	High IUU catches in the Indian Ocean First attempts to introduce a vessel monitoring system (VMS), develop a catch certification scheme (CDS) and monitor trade flows Closure of the fishery prior to 1 April	CM 118/XVII (118/XX) – obliges Contracting Parties to prohibit toothfish landings from Non-Contracting Parity vessels unless the fish was caught in compliance with CCAMLR Conservation Measures inside the CCAMLR Area or outside the CCAMLR Area CM 119/XVII (119/XX) – prohibits fishing by Contacting Party vessels in CCAMLR waters unless they had a Flag State licence setting out the time, place and species which they could fish CM 146/XVII – requires all licensed vessels to mark their fishing vessels and fishing gear appropriately to aid identification should equipment be lost at sea CM 170/XVIII – requires CCAMLR members to implement a CDS for *Dissostichus* spp to document international toothfish trade and certify that it has been caught in a manner consistent with CCAMLR conservation measures
1999/00	Adoption of CDS High IUU catches in some areas of the Southern Ocean Closure of fishing season prior to 15 April	CM 29/XIX – first introduced in 1991, this measure aims to minimise the incidental mortality of seabirds in the course of longline fishing the CCAMLR Area, it was amended in November 2000 to better capture the use of alternative line weighting regimes and the discharge of offal on the side of the vessel which is not used for fishing CM 147/XIX – requires inspection of all vessels licensed by Contracting Parties to fish for toothfish in the CCAMLR Area when they enter port of that or another Contracting Party
2000/01	CDS in operation High IUU catches continue in Indian Ocean Mauritius indicates that it will close Port Louis for IUU vessels	CM 148/XX – requires fin fishing vessels to have a mandatory and automated satellite-linked VMS from December 2000
2001/02	Exploratory fisheries opened	Including: CM 221/XX; 222/XX; 229/XX; 230/XX; 231/XX; 232/XX; 233/XX; 234/XX; 235/XX; 236/XX – TAC* of 5820 tonnes at South Georgia and precautionary TACs in all other areas including the exploratory fisheries
2002/03	CCAMLR concerned that continued IUU pressure will increase the potential for catastrophic stock declines CCAMLR approved a trail electronic WEB-based CDS in 2002/03 VMS trial to be instituted in 2002/03 A blacklist of vessels involved in IUU fishing approved	A new numbering system for observation and conservation measures was proposed at CCAMLR XXI to allow the measures to be traced over their history

*TAC = total allowable catch
Source Fallon and Kriwoken (*submitted*) – Adapted from CCAMLR 2002c; Kock 2001; Agnew 2000; Johanson 1997

Observation and conservation measures include (i) Flag State licensing requirements for all vessels in the fisheries, (ii) obligations on Flag States to prosecute and if necessary impose sanctions, (iii) observer and inspection schemes to monitor licensed vessels within the CCAMLR Area, (iv) trialling of a centralised VMS, (v) port inspections of landings and shipments, (vi) marking of vessels and shipping gear, (vii) introducing a blacklist of vessels engaged in IUU fishing, and (viii) a catch documentation scheme (CDS) to determine whether traded Patagonian toothfish have been caught in accordance with CCAMLR conservation measures. In particular, the CDS became binding on all CCAMLR State Parties in May 2000 to specifically monitor international Patagonian toothfish trade. It is designed to be started by fishing captains, completed by export customs official and checked by importing customs officials. According to Agnew (2000), the CDS is only the second international trade-related scheme to be introduced for marine fish by an international organisation.[1]

International Plan of Action

IUU fishing has also been recognised internationally with the adoption of the 2001 International Plan of Action (IPOA) on IUU Fishing by the FAO Committee on Fisheries (FAO 2001a; 2001b). This Action Plan outlines measures for exercising Flag State responsibility, the use of port and market measures and sanctions to control the actions of those involved in IUU fishing (Fallon and Kriwoken *submitted*). The IPOA has resulted in some measurable success – for example, Mauritius has now taken on international responsibilities and closed down its ports to potentially illegal Patagonian toothfish operations.

However, the IPOA places the onus on Port States to have clear evidence that vessels have been engaged in IUU fishing activities before refusing entry. Therefore, for Port States, particularly those with limited surveillance and resources, *that do wish to refuse access to IUU vessels the burden of proof is very high* (Lack & Sant 2001:16). Open ports, like Montevideo, continue to host IUU fishers.

Commercial extinction of the Patagonian toothfish

Given that commercial extinction of the Patagonian toothfish is estimated at less than 5 years if IUU continues at current levels (WWF 2002), that CCAMLR has been unable to prevent IUU fishing (Boyd 2002), and the implementation of protection measures continues to be slow, the challenge remains to impose effective controls on the open assess system before fishing and environmental resources are impaired.

[1] In 1992, the International Commission for the Conservation of Atlantic Tunas (ICCAT) adopted the Bluefin Tuna Statistical Document (BSD) program, which requires the use of an ICCAT-accepted reporting system to monitor trade in fresh and frozen bluefin tuna (ICCAT 1999).

9 Challenges for Patagonian toothfish management and conservation

The Patagonian toothfish fishery is characterized by uncertainty. The status of this species and stock assessments cannot be precisely determined. In addition, trade figures are inconclusive given that IUU catch figures are difficult to verify.

Despite the innovations introduced by the CCAMLR Commission, IUU Patagonian toothfish fishing continues unbaited. At its most recent meeting in Hobart in 2002, the CCAMLR Commission expressed concern that IUU fishing will increase the potential for catastrophic and precipitous declines in stock biomass if it is not brought under control.

The CCAMLR Commission must be commended on achieving the consensus necessary to introduce conservation measures, the IPOA and CDS and establishing a blacklist of vessels engaged in IUU fishing. Nevertheless the proposed CITES listing for Patagonian and Antarctic toothfish under Appendix II was strongly opposed by the majority of CCAMLR members at the twenty-first CCAMLR Commission meeting because they considered that it undermined the CDS and CCAMLR's competency (CCAMLR 2002c; WWF 2002). Australia subsequently withdrew its proposal on this issue at the following CITES (COP12) meeting in Chile (Kemp 2002). In addition, CCAMLR members only agreed to 'trial' an electronic CDS and centralised VMS to mitigate loopholes in these measures that enable illegal or fraudulent activities to continue, and that permit missing or incorrect information to be forwarded to the CCAMLR Commission (Fallon and Kriwoken *submitted*).

Given that commercial extinction for toothfish species is estimated at less than 5 years (WWF 2002), this species and threatened seabird and byctach populations may not survive unless governments, CCAMLR, the fishing industry, NGOs and consumers direct continued vigilance against IUU practises.

Considering that the current levels of illegal harvesting in the Patagonian toothfish fishery are unsustainable, the CCAMLR Commission and national governments regard that effective management and regulation of this resource is critical to ensure its survival (Agnew 2000). However, the Commission and national governments need to assess all options for improving the effectiveness of management of the species, particularly with regard to the wider implications of sustainability pertaining to changing cultural norms and practises that legitimise unlimited harvesting and mass consumption. In addition, the Commission needs to utilize other international instruments, including conventions and codes of practise, to support its own conservation measures and ensure that the potential of all initiatives to address IUU fishing are realised.

10 Global sustainability imperatives: some conclusions

The conservation of marine ecosystems may be considered in terms of intrinsic and instrumental values (Plate 10.1). These ecosystems are of value in and of themselves, irrespective of their social, environmental or economic significance to people. But it is the instrumental worth of marine ecosystems that tends to inform conservation practice and issues of governance in the Southern Ocean case. Clearly, in instrumental terms, it is important to ensure the long-term maintenance of marine ecosystems for enjoyment, inspiration and wealth (Ward 2000). Their structures and functions should be maintained as closely possible to their undisturbed state, and suffer neither irreversible effects from continued use nor negative effects that prevent adaptation to natural pressures.

Plate 10.1: Intrinsic values of the Southern Ocean © Christine Materia-Rowland

In instrumental terms, again, sustaining marine ecosystems involves making judgements about how marine resources might be used, and accepting the notion of limits. However, use values cannot be based on technical or ecological knowledge alone. Although this knowledge may inform the development of TACs set by governments to ensure that a fished population persists, it is also important to understand issues of supply and demand, production and consumption, and how these systems put pressure on individuals and groups to act in ways that do not respect limits or that jeopardise ecosystems.

In short, biophysical, socio-economic and cultural implications of the use of Southern Ocean resources and habitats are important and, together, they set the political climate within which ecosystem/human system management strategies need to operate (Fallon *work in progress*). Therefore, sustainability processes and outcomes depend on management and policy decisions that are adaptive and responsive to the unpredictability of ecosystems and socio-economic conditions. As a result, the sustainability of marine ecosystems is as much about social, cultural and economic considerations as it is about ecology, population dynamics and conservation.

Sustainability is an ethic of engagement related to questions of how to live and it is a set of substantive and procedural guidelines about managing our activities on the biosphere (Stratford *in press*). It is about ecological integrity, economic security, social well-being, and empowerment and responsibility (Institute for Sustainable Communities 2000). Its historical context is well-known, deriving from local, regional, national and international concerns about such matters as deforestation, desertification or the seas and oceans; about globalization, economic rationalism and resource distribution; and about health, well-being and sense of community.

In particular, certain principles of sustainability have been enshrined in international conventions such as Agenda 21 (United Nations 1992) or in national strategies for sustainable development, such as that formalised in the Australian Intergovernmental Agreement on the Environment, dating from 1992. These principles are (i) integration, (ii) public participation, (iii) intra- and inter-generational equity, (iv) precaution, (v) continual improvement, and (vi) the maintenance of diversity [and here we mean cultural as well as biological or geological diversity (Stratford and Davidson 2002)].

The principles of sustainability have been underpinned by a widespread decade-long commitment to the 'triple bottom line' model of sustainable development. This model is one that policy analysts, politicians, industry and community interests have adopted in rhetorical terms, but found less amenable to robust and resilient implementation on the ground.

The dilemmas posed by the conservation of the Patagonian toothfish and Southern Ocean resources and values affect each of the principles of sustainability. At a minimum, the maintenance of the species and of the *diversity* of its habitat requires vertical and horizontal *integration* of policy; the exercise of *precaution*; and high levels of *ecological literacy and knowledge*. This requirement is not abstract, but materially affects politicians, bureaucrats and the judiciary; commercial fishing operations and related industries; NGOs; fishing communities; scientists; and consumers. It also demands *public participation* in decision-making at various levels of government and governance, and at various spatial scales.

Public participation is especially problematic when resource management is at stake, because it is the vehicle by which issues of intra- and inter-generational equity are debated. For example, it may give American or other affluent consumers great comfort to buoycott the purchase of Patagonian toothfish on the presumption that their actions may positively affect conservation outcomes so that future generations of humans are able to have, as part of their stock of natural assets, a diverse and healthy Southern Oceans ecosystem. But their actions for the future may have unintended consequences in the present, such that the loss of valuable markets for Patagonian toothfish could seriously and negatively affect fishers, fishing operations, and communities throughout the world whose members depend on these.

Alternatively, trade in Patagonian toothfish may become hidden (or converse) as operators unload their products elsewhere.

The trade-offs between intra-generational equity and provisioning for the future are often at the centre of significant conflicts that, at face value, appear to be about resources rather than human welfare and well-being. The management of the Patagonian toothfish industry – which must, in our view, be recognised as the *management of people* in the industry and ecosystem – needs to be sensitive to these issues of equity. Here, it is also important to consider suggestions that open-access resources (or resources on the high seas) could (or in the minds of some – should) be managed as ‘property rights’ that can be bought or exchanged between operators. This mechanism would be similar to the property rights granted to operators within EEZs under state jurisdiction. It is contended that fishers will protect their own interests if they ‘own’ the resource. But the oceans and high seas belong to the commons. Hence, the task will be to move from ideas of ownership by communities of interest narrowly circumscribed by sovereignty or association with business, to ownership as stewardship – the idea of caring for regions that are common property for the benefit of humanity in its entirety and for the benefit of non-human nature and the ecosystems on which its members depend.

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References

AAD (2001a). A history of the Patagonian toothfish fishery. *Australian Antarctic Magazine,* Australian Antarctic Division (AAD), Hobart, Australia.

AAD (2001b). *Seabird mortality on longline fisheries: What are longline fisheries?* Australian Antarctic Division, Hobart, Australia. http://www-new.aad.gov.au/default.asp?casid=1052 Accessed 18 December 2001.

AAD (2002). *Toothfish: 10 facts*. Australian Antarctic Division, Hobart, Australia. http://www-aadc.aad.gov.au/ten_facts/fish/toothfish.asp, Accessed 7 October 2002.

AFMA (2001). *Commonwealth fisheries: Heard Island and McDonald Islands fishery*. Australian Fisheries Management Authority (AFMA), Canberra, Australia, http://www.afma.gov.au/fisheries/heard%20and%20mcdonald%20islands/default.php, Accessed 10 July 2002.

AFMA (2002). *Report on the key outcomes of the twenty-first meeting of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR XXI).* Australian Fisheries Management Authority (AFMA), Canberra, Australia.

Agnew, D.J. (1997). Review: The CCAMLR ecosystem monitoring programme. *Antarctic Science*, 9(3), 235-242.

Agnew, D.J. (2000). The illegal and unregulated fishery for toothfish in the Southern Ocean, and the CCAMLR catch documentation scheme. *Marine Policy*, 24, 361-374.

Agnew, D.J. and Nicol, S. (1996). Marine disturbances: Commercial fishing. *Foundation for Ecological Research West of the Antarctic Peninsula, Antarctic Research Series*, 70, 417-435.

Agnew, D.J. and Phegan, G. (1995). A fine-scale model of the overlap between penguin foraging demands and the krill fishery in the South Shetland Islands and Antarctic Peninsula. *CCAMLR Science*, 2, 99-110.

Alexander, K., Robertson, G. and Gales, R. (1997). The incidental mortality of albatrosses in longline fisheries. A report on the workshop from the *First International Conference on the Biology and Conservation of Albatrosses*, Australian Antarctic Division, September 1995, Hobart, Australia.

Ashford, J.A. (2001). *In support of a rationally managed fishery: Age and growth in Patagonian toothfish* (*Dissostichus eleginoides*). Unpublished Doctoral Dissertation, Old Dominion University, Durham, UK.

ASOC (1998). *Patagonian toothfish moratorium*. Antarctic and Southern Ocean Coalition (ASOC), Washington, USA, http//www.asoc.org/, Accessed 10 July 2002.

ASOC (2002a). Pirate fishing: Out of control. *Eco*, ATCM XXV, No 3, Antarctic and Southern Ocean Coalition (ASOC), Tasmanian Conservation Trust, Hobart, Australia.

Austral Fisheries Pty Ltd (2002). *The alphabet boats: A case study of toothfish poaching in the Southern Ocean*. Austral Fisheries Pty Ltd, Mt Hawthorn, Australia.

Australia (1993). *The Antarctic Treaty System*. Commonwealth of Australia, Canberra, Australia.

Birdlife International (2001). *Longlining statistics. The global seabird conservation program.* Birdlife International, http://www.savethealbatross.org.za/stats.htm, Accessed 10 July 2002.

Birdlife International (2002). *Save the albatrosses: Pirate fishing. The global seabird conservation program.* Birdlife International, http://www.birdlife.net/action/campaigns/save_the_albatross/pirate_fishing.html, Accessed 10 July 2002.

Bjordal, Å. and Løkkeborg, S. (1996). *Longlining*. Fishing New Books, Cambridge University Press, Cambridge, UK.

Boyd, D. (2002). After the Protocol: Problems and prospects for Antarctica. In Jabour-Green, J. and Haward, M. (eds.), *The Antarctic: Past, present and future*, Antarctic CRC Research Report No 28, University of Tasmania, Hobart, Australia, 105-111.

Brothers, N.P. (1991). Albatross mortality and associated bait loss in the Japanese longline fishery in the Southern Ocean. *Conservation Biology*, 55, 225-268.

Bush, W.M. (2002). The next 40 years the challenges of economic globalization and 21st century security threats. In Jabour-Green, J. and Haward, M. (eds.), *The Antarctic: Past, present and future*, Antarctic CRC Research Report No 28, University of Tasmania, Hobart, Australia, 126-146.

Cascorbi, A. (2002). *Seafood watch, seafood report: Chilean seabass: Patagonian toothfish (Dissostichis eleginoides) and Antarctic toothfish (Dissostichis mawsoni)*. Draft Report No 1, Monterey Bay Aquarium, USA.

Constable, A.J. (2002). The status of Antarctic fisheries research. In Jabour-Green, J. and Haward, M. (eds.), *The Antarctic: Past, present and future*, Antarctic CRC Research Report No 28, University of Tasmania, Hobart, Australia, 71-84.

Constable. A.J., de la Mare, W.K., Agnew, D.J., Everson, I. and Miller, D. (2000). Managing fisheries to conserve the Antarctic marine ecosystem: Practical implementation of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR). *ICES Journal of Marine Science*, 57, 778-791.

CCAMLR (1988). *Report of the seventh meeting of the Commission.* Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), Hobart, Australia.

CCAMLR (2000). *Statistical bulletin volume 12*. Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), Hobart, Australia, http://www.ccamlr.org/pu/e/pubs/sb/evol15.htm, Accessed 10 April 2002.

CCAMLR (2002a). *Understanding CCAMLR's approach to management*. Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), Hobart, Australia, http://www.ccamlr.org/pu/e/pubs/am/toc.htm, Accessed 26 November 2002.

CCAMLR (2002b). *Fisheries in Areas 48, 58 and 88*. Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), Hobart, Australia, http://www.ccamlr.org/pu/e/sc/fish-monit/areas.htm, Accessed 26 November 2002.

CCAMLR (2002c). *Report of the twenty-first meeting of the Commission*. Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), Hobart, Australia.

CCAMLR (2002d). *Statistical bulletin: Volume 14 (1992-2001).* Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), Hobart, Australia.

CCAMLR (2003). *Convention introduction*. Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), Hobart, Australia, http://www.ccamlr.org/pu/e/conv/map2.htm, Accessed 24 March 2003.

CCAMLR (2003). *CCAMLR logo*. Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), Hobart, Australia, http://www.ccamlr.org, Accessed 24 March 2003.

Chikov, V.N. and Melnikov, Y.S. (1990). On the question of fecundity of the Patagonian toothfish in the region of the Kerguelen Islands. *Journal of Ichthyology*, 30(3), 122-125.

Constable, A.J. (2002). The status of Antarctic fisheries research. In Jabour-Green, J. and Haward, M. (eds), *The Antarctic: Past, present and future*, Antarctic CRC Research Report No 28, University of Tasmania, Hobart, Australia, 71-84.

Constable. A.J., de la Mare, W.K., Agnew, D.J., Everson, I. and Miller, D. (2000). Managing fisheries to conserve the Antarctic marine ecosystem: Practical implementation of the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR). *ICES Journal of Marine Science*, 57, 778-791.

Croxall, J.P. and Gales, R. (1998). An assessment of the conservation status of albatrosses. In Robertson, G. and Gales, R. (eds), *The albatross: Their biology and conservation*. Surrey Beatty and Sons, Chipping Norton, Australia. 46-65.

CQFE (2002a). *Demersal longline equipment in the fishery Patagonian Toothfish*. Centre for Quantitative Fisheries Ecology (CQFE), http://www.odu.edu/sci/cqfe/age&growth/Pat-tooth/Stock-ass.htm, Accessed 12 September 2002.

CQFE (2002b). *What do we know about the Patagonian toothfish?* Centre for Quantitative Fisheries Ecology (CQFE), <http://www.odu.edu/sci/cqfe/age&growth/Patagonian%20toothfish/toothfish.htm> Accessed 12 September 2002.

CSIRO (1998). *Patagonian toothfish*. Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) – Division of Marine Research, Hobart, Tasmania.

CSIRO (2000). *The facts: Understanding our oceans. Southern Ocean and Antarctic circumpolar current*. Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) – Division of Marine Research, Hobart Australia.

Dodds, K. (2000). Geopolitics, Patagonian toothfish and living resource regulation in the Southern Ocean. *Third World Quarterly*, 21(2), 229-246, Accessed 1 August 2002.

Eastman, J.T. (1985). The evolution of neutrally buoyant notothenioid fishes: Their specialisations and potential interactions in the Antarctic marine food web. In Siegfried, W.R., Condy, P.R. and Lawes, R.M. (eds), *Antarctic nutrient cycles and food webs*, Springer-Verlag, Heidelberg, Germany.

Eastman, J.T. and deVries, A. (1981). Buoyancy adaptations in a swim-bladderless Antarctic fish. *Journal of Morphology*, 167, 91-102.

ECO (2001). It's the environment stupid! *ECO 4*, CCAMLR XX, Friends of the Earth, Hobart, Tasmania.

Ecoceanos (2000). The U.S.A. will increase regulation of fishing imports from Chile and Antarctic Aguas. *Ecoceanos News*, 22 March 2000, Ecoceanos Centre for the Conservation and the Sustainable Development, Santiago, Chile.

El-Sayed, S.Z. (1978). Primary production and estimates of potential yields of the Southern Ocean. In McWhinnie (ed.), *Polar research to the present and the future*, AAAS Selective Symposium, 7, 141-160.

Everson, I. (2001). A comparison between otoliths and scales for use in estimating the age of *Dissostichus eleginoides* from South Georgia. *CCAMLR Science*, 8, 75-92.

Evseenko, S.A., Kock, K-H and Nevinsky, M.M. (1998). Early life history of the Patagonian toothfish, *Dissostichus eleganoides*, in the Atlantic sector of the Southern Ocean. *Antarctic Science*, 7(3), 221-226.

Fallon, L.D. (*work in progress*). *The role of state and non-state actors in the management of Patagonian toothfish (Dissostichus eleginoides)*. Unpublished Doctoral Dissertation, School of Geography and Environmental Studies, University of Tasmania, Hobart, Tasmania.

Fallon, L.D. and Kriwoken, L.K. (*submitted*). *International influence of an Australian non-governmental organisation in the protection of Patagonian toothfish*. University of Tasmania, Hobart, Australia.

FAO (2000). *The state of world fisheries and aquaculture: Part 2: Selected issues facing fishers and aquaculturists*. Food and Agriculture Organisation (FAO), Rome, Italy, http://www.fao.org/DOCREP/003/X8002E/X8002E00.HTM, Accessed 10 April 2002.

FAO (2001a). *International plan of action to prevent, deter and eliminate illegal, unreported and unregulated fishing*. Food and Agriculture Organisation (FAO), Rome, Italy, http://www.fao.org/DOCREP/003/y1224E/Y1224E00.HTM, Accessed 11 April 2002.

FAO (2001b). *International plan of action to prevent, deter and eliminate illegal, unreported and unregulated fishing*. Report of the twenty-fourth session of the FAO Committee on Fisheries, 26 February – 2 March 2001, Food and Agriculture Organisation (FAO), Rome, Italy.

FAO (2002a). *Code of conduct for responsible fisheries*. Food and Agriculture Organisation (FAO), Rome, Italy, http://www.fao.org/fi/agreem/codecond/codecon.asp, Accessed 10 April 2002.

FAO (2002b). *Agreement to promote compliance with international conservation and management measures by fishing vessels on the high seas*. Food and Agriculture Organisation (FAO), Rome, Italy, http://www.fao.org/legal/treaties/012t-e.htm, Accessed 10 April 2002.

Greenpeace (2000). *Albatrosses hooked and drowned*. Greenpeace, Amsterdam, The Netherlands, http://archive.greenpeace.org/~oceans/piratefishing/albatross.html, Accessed 10 July 2002.

Haward, M., Bergin, A. and Hall, H.R. (1998). International legal and political bases to the management of the incidental catch of seabirds. In Robertson, G. and Gales, R. (eds), *Albatross biology and conservation*, Surrey Beatty & Sons, Chipping Norton, UK.

Hempel, G. (1987). The krill-dominated pelagic system of the Southern Ocean. *Environment International*, 13, 33-36.

Hosie, G.W. (1994). Multivariate analyses of the macrozooplankton community and euphausid larval ecology in the Prydz Bay region, Antarctica. *ANARE Report Series 137*, Australian Antarctic Division, Hobart, Australia.

ICCAT (1999). *Current management recommendations and related resolutions adopted by ICCAT for the conservation of Atlantic tunas and tuna-like species*. International Commission for the Conservation of Atlantic Tunas, Madrid, Spain.

Institute for Sustainable Communities (2000). http://www.iscvt.org/Saqscele.htm, Accessed November 2002.

ISOFISH (1998a). *The Vikings: The involvement of Norwegian fishermen in illegal and unregulated longline fishing for Patagonian toothfish in the Southern Ocean*. ISOFISH Occasional Report No 3, International Southern Oceans Longline Fisheries Information Clearing House (ISOFISH), Hobart, Australia.

ISOFISH (1998b). *The involvement of Mauritius in the trade in Patagonian toothfish from illegal and unregulated longline fishing in the Southern Ocean and what might be done about it*. ISOFISH Occasional Report No 1, International Southern Oceans Longline Fisheries Information Clearing House (ISOFISH), Hobart, Australia.

ISOFISH (1999a). *The Chilean fishing industry: Its involvement in and connections to the illegal and unregulated exploitation of Patagonian toothfish in the Southern Ocean*. ISOFISH Occasional Report No 2, International Southern Oceans Longline Fisheries Information Clearing House (ISOFISH), Hobart, Australia.

ISOFISH (1999b). *ISOFISH logo*. International Southern Oceans Longline Fisheries Information Clearing House (ISOFISH), Hobart, Australia.

ISOFISH (2002). *Background longline fishing techniques: Patagonian toothfish profile*. International Southern Oceans Longline Fisheries Information Clearing House (ISOFISH), Hobart, Australia, http://www.isofish.org.au/backg/fishing.htm, Accessed 22 February 2002.

Johanson, J.M. (1997). *The CCAMLR Ecosystem approach to the management of marine harvesting*. Unpublished Doctoral Dissertation, Institute of Antarctic and Southern Ocean Studies (IASOS), University of Tasmania, Hobart, Tasmania.

Kaimieniecki, S. and Scully Granzeier, M. (1998). Eco-cultural security and indigenous self-determination: Moving toward a new conception of sovereignty. In Litfin, K. T. (ed.), *The greening of sovereignty in world politics*. MIT press, Cambridge, UK, 258-274.

Kemp, D. (2002). *Australia champions marine species protection at international conference*. Media Release 19 November 2002, Minister for the Environment and Heritage, Commonwealth of Australia, Canberra, Australia.

Knox, G.A. (1994). *The Biology of the Southern Ocean*. Cambridge University Press, Cambridge, 1-347.

Kock, K-H. (1992). *Antarctic fish and fisheries*. Cambridge University Press, Cambridge, UK.

Kock, K-H. (1994). Fishing and conservation in southern waters. *Polar Record*, 30(172), 3-22.

Kock, K-H. (2001). The direct influence of fishing and fishery-related activities on non-target species in the Southern Ocean with particular emphasis on longline fishing and its impact on albatrosses and petrels: A review. *Reviews in Fish Biology and Fisheries*, 11, 31-56.

Kock, K-H. and Shimadzu, Y. (1994). *Trophic relationships and trends in population size and reproduction parameters in Antarctic high-level predators. Southern Ocean Ecology*: The BIOMASS perspective, Cambridge University Press, Cambridge, 287-309.

Kock, K-H., Duhamel, G. and Hureau, J.C. (1985). *Biology and status of exploited Antarctic fish stocks: A review*. BIOMASS Scientific Series, 6, 1-143.

Kriwoken, L.K. and Williamson, J.W. (1993). Hobart, Tasmania: Antarctic and Southern Ocean connections. *Polar Record*, 169, 93-102.

Lack, M. and Sant, G. (2001). *Patagonian toothfish: Are conservation and trade measures working?* TRAFFIC Bulletin 19(1), 1-19.

Løkkeborg, S.L. (1999). General description of longline fishing. In Brothers, N., Cooper, J. and Løkkeborg, S.L. (eds), *The incidental catch of seabirds by longline fisheries: Worldwide review and technical guidance for mitigation*. Volume 937, Food and Agriculture Organisation (FAO) Fishing Circular.

Masters, C. (2002). *The toothfish pirates*. Four Corners Documentary, Australian Broadcasting Commission, 30 August 2002, Australia.

McElroy, J.K. (1984). Antarctic fisheries: history and prospects. *Marine Policy*, July 1984, 239-257.

Miller, D.G. (1991). Conservation of Antarctic marine living resources: A review and South African perspective. *South African Journal of Antarctic Research*, 21(2), 130-142.

Montgomery, B. (2002). A fishy business: Australia is toughening its war on the Southern Ocean's toothfish pirates. *The Weekend Australian*, 26-27 October 2002, Australia.

National Geographic (2002). U.S. chefs join campaign to save Chilean seabass. *National Geographic News*, http://news.nationalgeographic.com/news/2002/05/0522_020522_seabass.html, Accessed 7 October 2002.

Nicol, S. (1991). CCAMLR and its approaches to management of the krill fishery. *Polar Record*, 27, 229-236.

Nicol, S. and de la Mare, W.K. (1993). Ecosystem management and the Antarctic krill. *American Scientist*, 81, 36-47.

Nicol, S. and Endo, Y. (1997). *Krill fisheries of the world*. Food and Agriculture Organisation (FAO) Fisheries Technical Paper, 367, p. 100.

Perry, M. (1998). Australia rallies against Antarctic 'fish pirates'. *Reuters Limited*, http://www.gue.com/news/fishpirates.html, Accessed 7 October 2002.

Preston, G.L., Chapman, L.B. and Watt, P.G. (1998). *Vertical longlining and other methods of fishing around fish aggregating devices (FADs): A manual for fishermen*. Secretariat of the Pacific Community, Noumea, New Caledonia.

Robertson, G. (2001). Can albatrosses and longline fisheries co-exist? *Australian Antarctic Magazine,* Australian Antarctic Division, Hobart, Australia.

Rothwell, D.R. (1998). The Antarctic Treaty System and the Southern Ocean. In Bateman, S, and Rothwell, D. R. (eds), *Southern Ocean fishing: Policy challenges for Australia*, Centre for Maritime Policy, University of Wollongong, Wollongong, Australia, 5-40.

Ryan, P.G. and Watkins, B.P. (2000). *Seabird bycatch in the Patagonian toothfish longline fishery at the prince Edward Islands: 1999-2000*. Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), Hobart, Australia, WG-FSA-00/30, p. 13.

SC-CCAMLR (2002). *Report of the Working Group on Fish Stock Assessment*. Twenty-first meeting of the Commission. Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), Hobart, Australia.

Scott, J. (1994). *Marine conservation at Macquarie Island*. Tasmanian Parks and Wildlife Service, Hobart, Australia.

SeaWeb (2000). Ocean Update. *SeaWeb*, 5(4), Washington USA.

Simon, C. (1982). Polynas surrounded by ice and mystery. *Science News*, 24, 122:183, http://www.science-frontiers.com/sf024/sf024p13.htm, Accessed 17 December 2002.

Stone, S. (2002a). *Japan criticised over Antarctic whaling activity*. Media Release 2 January 2002, Parliamentary Secretary to the Minister for the Environment and Heritage, Commonwealth of Australia, Canberra, Australia.

Stone, S. (2002b). *Major blow to illegal fishers*. Media Release 11 June 2002, Parliamentary Secretary to the Minister for the Environment and Heritage, Commonwealth of Australia, Canberra, Australia.

Stonehouse, B. (ed.) (2002). *Encyclopaedia of Antarctica and the Southern Oceans*. Scott Polar Research Institute, John Wiley and Sons Ltd, Chichester, UK.

Stratford, E. (*in press*). *Tasmania Together and the rhetoric of island and development: Latent opportunities for agonism and innovation, World Development*.

Stratford, E. and Davidson, J. (2002). Capital assets and intercultural borderlands: Sociocultural challenges for natural resource management, *Journal of Environmental Management*, 64, 1-12.

Tonnessen, J.N. and Jonhsen, A.O. (1982). *The history of modem whaling*. Hurst/Australian National University, London, UK.

TRAFFIC (2001a). *Patagonian toothfish: Are conservation measures working*. Trade Records Analysis of Flora and Fauna in International Commerce (TRAFFIC), http://www.traffic.org/toothfish/tooth1.html, Accessed 8 August 2002.

TRAFFIC (2001b). *Patagonian toothfish: Are conservation measures working*: *The Patagonian toothfish fishery*. Trade Records Analysis of Flora and Fauna in International Commerce (TRAFFIC), http://www.traffic.org/toothfish/tooth2.html, Accessed 8 August 2002.

TRAFFIC (2001c). *Patagonian toothfish: Are conservation measures working: Illegal fishing continues to threaten Patagonian Toothfish*. Trade Records Analysis of Flora and Fauna in International Commerce (TRAFFIC), http://www.traffic.org/toothfish/index.html, Accessed 8 August 2002.

TRAFFIC (2001d). *Patagonian toothfish: Are conservation measures working: Discussion and conclusion*. Trade Records Analysis of Flora and Fauna in International Commerce (TRAFFIC), http://www.traffic.org/toothfish/tooth5.html, Accessed 8 August 2002.

TRAFFIC and WWF (2002). *A CITES priority: TRAFFIC and WWF briefing document*. World Patagonian toothfish and Antarctic toothfish at the twentieth meeting of the Conference of Parties to CITES (COP12), Santiago, Chile, 2002, Trade Records Analysis of Flora and Fauna in International Commerce (TRAFFIC) and World Wildlife Fund (WWF), Surrey, UK.

United Nations (1992). *United Nations Conference on Environment and Development – Agenda 21.* http://www.un.org. Accessed November 2002.

United Nations (2001). *The United Nations agreement for the implementation of the provisions 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 (in force as from 11 December 2001).* Oceans and Law of the Sea, Division of Ocean Affairs and the Law of the Sea, http://www.un.org/Depts/los/convention_agreements/convention_overview_fish_stocks.htm, Accessed 10 April 2002.

Walton, D.W. (1987). *Antarctic Science*. Cambridge University Press, Cambridge.

Wapner, P. (1998). Reorienting state sovereignty: Rights and responsibilities in the environmental age. In Litfin, K. T. (ed.), *The greening of sovereignty in world politics*. MIT Press, Cambridge, UK, 276-297.

Ward, T.J. (2000). Indicators for assessing the sustainability of Australia's marine ecosystems. *Marine Freshwater Research*, 51, 435-446.

Waterhouse, E.J. (ed.) (2001). *Ross Sea region 2001: A state of the environment report for the Ross Sea region of Antarctica*. New Zealand Antarctic Institute, Christchurch, New Zealand.

Weddell, J. (1825). *Voyage towards the South Pole*.

WG-FSA (1998). *Report of the working group on fish stock assessment (SC-CCAMLR)*. Annex 5 in the report of the seventeenth meeting of the Scientific Committee, Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), Hobart, Australia.

WG-FSA (1999). *Report of the working group on fish stock assessment (SC-CCAMLR)*. Annex 5 in the report of the eighteenth meeting of the Scientific Committee, Commission for the Conservation of Antarctic Marine Living Resources, Hobart, Australia.

WG-FSA (2000). *Report of the working group on fish stock assessment (SC-CCAMLR)*. Annex 5 in the report of the nineteenth meeting of the Scientific Committee, Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), Hobart, Australia.

WG-FSA (2002). Report of the working group on fish stock assessment (SC-CCAMLR). In the report of the *Twenty-first meeting of the Commission. Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR),* Hobart, Australia.

WG-IMAG (2002). Incidental mortality of seabirds during unregulated longline fishing in the Convention Area: Working Group on Incidental Mortality Arising from Fishing. In the report of the *Twenty-first meeting of the Commission. Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR),* Hobart, Australia.

Williams, R. (2001). About Patagonian toothfish. *Australian Antarctic Magazine*, Australian Antarctic Division (AAD), Hobart, Australia.

Williams, R. and de la Mare, W.K. (1995). Fish distribution and biomass in the Heard Island Zone (Division 58.5.2). *CCAMLR Science*, 2, 1-20.

WWF (2002). *Illegal trade will continue to decimate toothfish populations*. Media Release 14 November 2002, World Wildlife Fund Australia, Sydney, Australia.

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Liza also has considerable industry experience. Over the past few years she has worked as an Oceans Planning Officer with the Australian National Oceans Office and a Hydrographical Scientific Officer with the Tasmanian Department of Primary Industries, Water and Environment. She has also completed four voyages to Antarctica with the Australian National Antarctic Research Expeditions (ANARE) as biologist, hydrologist and laboratory manager, as well as undertaking the responsibilities of Environment Officer at the Australian Antarctic Division.

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