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THE INCIDENTAL CATCH OF SEABIRDS BY LONGLINE FISHERIES: WORLDWIDE REVIEW AND TECHNICAL GUIDELINES FOR MITIGATION

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THE INCIDENTAL CATCH OF SEABIRDS BY LONGLINE FISHERIES: WORLDWIDE REVIEW AND TECHNICAL GUIDELINES FOR MITIGATION

Prepared by

Nigel P. Brothers
Parks & Wildlife Service, GPO Box 44A, Hobart 7001, Tasmania, Australia

John Cooper
Birdlife International Seabird Conservation Programme
Avian Demography Unit
Department of Statistical Sciences
University of Cape Town, Rondebosch 7700, South Africa
(jcooper@botzoo.uct.ac.za)

Svein Løkkeborg
Institute of Marine Research, P.O. Box 1870, N5024 Bergen, Norway
(svein.lokkeborg@imr.no)

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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PREPARATION OF THIS DOCUMENT.

At the twenty-second session of FAO's Committee on Fisheries (COFI) in March 1997 it was proposed that FAO should organize, using extra-budgetary funds, an expert consultation to develop guidelines leading to a plan of action aimed at reducing the incidental catch of seabirds in longline fisheries. The Governments of the USA and Japan agreed to fund and collaborate with FAO in organizing such a consultation. A three-step process including (i) establishing, and a meeting of, a steering committee with representatives from the funding Governments and FAO, (ii) forming, and a meeting of, a Technical Working Group (TWG) of FAO appointed experts and finally, (iii) a FAO Consultation which should consider and eventually approve a plan of action. The process has been coordinated with simultaneous FAO efforts to prepare plans of action for management of sharks and fishing capacity.

The steering committee decided on content and lead authorship of three background papers to be prepared for review by the Technical Working Group:

- A description of pelagic and demersal longline fisheries (*Svein Løkkeborg*)
- The bycatch of seabirds in specific longline fisheries: A worldwide review (*John Cooper*)
- A review of longline seabird bycatch mitigation measures and their effect on other marine species (*Nigel Brothers*)

The TWG at its meeting in Tokyo, 25-27 March 1998, decided to compile the contents of the three papers into one publication, which was subsequently done under the leadership of one of the authors, John Cooper. This draft document was later edited by the Fishing Technology Service of the Fisheries Department of FAO under the leadership of John W. Valdemarsen.

The document intends to provide relevant information about longline fisheries around the world, the associated incidental catch of seabirds and how the problem can be minimized and partly solved by using technical mitigation measures. As such it should be a useful tool for States which decide to develop a national plan of action as part of the International Plan of Action for Reduciing Incidental Catch of Seabirds in Longline Fisheries adopted by COFI at its 23rd Session in March 1999 and endorsed by the FAO Council at its 116th Session in June 1999.

ACKNOWLEDGEMENTS

Acknowledgements are given to the many people who supplied unpublished and "grey" literature and fishery statistics, commented on the drafts and shared their knowledge and insight with the lead authors. Such thanks are particularly addressed to the fellow members of the TWG and to separate reports prepared by M. Sigler (ground fish in Alaska), B. Trumble (Pacific halibut) and Y. Uosumi (Japanese tuna longline fishery).

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ABSTRACT

The content of this report was originally prepared as three separate background papers describing longline fisheries of the world, the nature and extent of incidental catch of seabirds in those fisheries and a description of technical and operational measures that can mitigate such incidental catch. An FAO appointed Technical Working Group (TWG) of experts in the field of fishing technology, seabird biology and fisheries management reviewed the content and decided to compile it into one document.

The report, first in general terms, describes the interaction of seabirds with longline fisheries with reference to typical behaviour patterns of seabirds and why and how the incidental longline catch of seabirds has become an international issue.

The various longline fisheries (demersal and pelagic) of the world are described with regard to technology and effort. The pelagic fisheries, which mainly target tunas, swordfish and billfishes are operated widely from temperate to tropical waters in all oceans. The most important demersal fisheries are found in the North Atlantic and the North Pacific but a longline fisheries for Patagonian tootfish has been developed in the Southern Ocean over the last few years.

Certain longline fisheries result in large numbers of seabirds being hooked on setting lines. The major "problem" fisheries are the demersal fisheries of the Northeast Pacific, North Atlantic, Southern Ocean and the Atlantic coast of South America, and the tuna pelagic fisheries of cool temperate seas in the North Pacific and the Southern Ocean. However, data on the incidental catch of seabirds are lacking for a number of longline fisheries, including the Pacific coast of South America, the Mediterranean Sea and in tropical waters of all oceans. Species of seabirds most commonly taken are the albatrosses and large petrels of the family Procellariidae.

A comprehensive number of mitigation measures for reducing the incidental catch of seabirds in longline fisheries has been developed during the past 5-10 years. These are all described in detail in the report. With widespread use of such mitigation measures, a significant reduction in incidental catch of seabirds is achievable at a minimal cost and with much potential financial benefit to longline fisheries.

Distribution:

Participants in Consultation on the Management of Fishing Capacity, Shark Fisheries and Incidental Catch of Seabirds in Longline Fisheries, FAO Rome, October 1998
Members of Seabird Technical Working Group, Tokyo, March 1998
Directors of Fisheries
Fisheries Officers in FAO Regional and Subregional Offices

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1. GENERAL INTRODUCTION

Seabirds, here defined as those species that habitually obtain their food from the sea below the low water mark, are found in all the world's oceans and seas. Generally speaking the numbers of individuals and species are higher in colder, more productive waters, as are found in upwelling situations on continental shelves, at oceanic fronts and in high latitudes. Tropical oceans away from land masses generally support low densities of relatively few species of seabirds. There is thus a broad matching of seabird abundance with the world's most fished seas: both seabirds and fishing vessels concentrate in areas of high biological productivity. Because all seabirds need to return to land to breed, and often to localities where they are safe from terrestrial predators, seabird numbers are often highest in the vicinity of coastal cliffs and offshore and oceanic islands. However, large foraging ranges and deferred maturity, coupled with ocean-wide migration and dispersal patterns, mean that many seabirds, especially prebreeders that may form 50% of the population, range over huge areas of ocean.

Interactions between seabirds and fisheries have existed since humans first went to sea to catch fish. In the last quarter century concerns have been expressed on the deleterious effects of various types of fishing activities on seabirds (e.g. King *et al.* 1979, Duffy & Schneider 1994, Dunn 1995, Hilden 1997). The sometimes huge numbers of seabirds killed by high-seas drift nets (e.g. Northridge 1991, DeGange *et al.* 1993, Johnson *et al.* 1993, Ogi *et al.* 1993) contributed to their banning in 1993. Longlining, by contrast with drift-netting, has been regarded as a species and size-selective fishing technique which is "environmentally friendly" (Bjordal & Løkkeborg 1996, but see Hinman *et al*. 1998 for a contrary view).

With notable exceptions among the penguins, alcids (auks and allies) and cormorants, seabirds are primarily surface foragers, taking their prey from the top few metres of the sea only (Ashmole 1971, Harper *et al.* 1985). As well as being predators of marine life, many seabirds are also scavengers, taking dead and moribund fish, squid and other animals found floating on the sea surface. Surface-scavenging makes seabirds "preadapted" to supplement their food requirements from that available from fishing vessels, either as discards (e.g. Camphuysen *et al.* 1995) or by stealing baits from hooks. It is the latter behaviour that leads to seabird mortality, especially from longline fishing operations. Seabirds that are commonly hooked in this way are albatrosses, petrels, shearwaters, gulls and skuas. Deep-diving and non-scavenging species, such as penguins, cormorants and auks, are rarely caught on longlines. Seabird size is also of relevance: the smaller seabirds (e.g. terns, storm petrels and auklets) are unable to swallow such large food items as longline baits, and as a consequence, they are rarely found captured in this way.

Longliners may operate up to 35 000 hooks/day. Typically, longlines are set from the vessel's stern while it moves forward at three to six knots. Baited hooks do not always sink immediately on reaching the sea surface, being kept afloat for a varying period of time by tension on the line and by turbulence from the stern and propeller. It is during this time that seabirds may seize the bait, with some becoming hooked. Normally, the weight of the line drags hooked birds below the sea surface and drowns them. Some (but far fewer) birds may be caught during hauling, mainly by entanglement as they try to take still-baited hooks or by flying into the line (e.g. Huin & Croxall 1996). The fact that seabirds (especially those that scavenge) have large gapes and are thus able to swallow large food items whole makes them also liable to get caught on longlines.

Recently, growing concern has been expressed over the numbers of seabirds, especially but not only the albatrosses of the Southern Ocean, that are killed by longlines (e.g. Tennyson 1990, Brothers 1991, Gales 1993, Kalmer *et al*. 1996, Alexander *et al.* 1997, Brothers *et al*. 1998a, Croxall 1998, Croxall & Gales 1998, Weimerskirch *et al.* 1998). A number of field and modelling studies (e.g. Weimerskirch & Jouventin 1987, Croxall *et al.* 1990, de la Mare & Kerry 1994, Moloney *et al.* 1994, Prince *et al.* 1994, Tuck & Polacheck 1995, Croxall *et al*. 1996, Woehler 1996, Weimerskirch *et al.* 1997, Croxall *et al*. 1998 Weimerskirch & Jouventin 1998) has shown that many southern albatross populations are in decline, at least partially because of longline-induced mortality.

As a consequence of this concern, fishing nations, fishing industry, intergovernmental bodies (such as international fishing commissions) and non-governmental organizations have commenced studies of the levels of seabird mortality caused by longline fisheries and how mortality rates may be reduced to improve the conservation status of the affected species (e.g. Bergin 1997, Haward *et al.* 1998). Examples of such activities are the national research efforts and mitigatory regulations of countries such as Australia, France, Japan, New Zealand, Norway, South Africa, United Kingdom and the USA (e.g. Evans 1996, CCSBT 1997, National Marine Fisheries Service 1997a,b, Environment Australia 1998, Fadely *et al.* 1998); several attempts to develop underwater setting devices by industry (Barnes & Walshe 1997, Smith & Bentley 1997, Løkkeborg 1998), the work of scientific committees and working groups of the Commissions for the Conservation of Antarctic Marine Living Resources and for the Conservation of Southern Bluefin Tuna; and the Seabird Conservation Programme of BirdLife International (Wanless & Cooper 1998).

An important impetus for action was the resolution "Incidental Mortality of Seabirds in Longline Fisheries" adopted by the World Conservation Union (IUCN) at its First World Conservation Congress in Montreal, Canada in October 1996. This resolution *inter alia* called upon states to reduce seabird mortality to "insignificant levels for affected species" (IUCN 1997). Further, in April 1997 at the instigation of Australia and The Netherlands with earlier support from South Africa and Uruguay (Barea *et al*. 1994) the world's albatrosses were listed in the Appendices of the Convention on the Conservation of Migratory Species of Wild Animals (CMS or the Bonn Convention), leading the way for a range-state Agreement to improve their poor conservation status (CMS 1997a,b, B. Baker *in litt*., G. Boere *in litt.*). Longline-induced mortality formed a significant part of the justification for this listing.

Longline fishing methods are described in section 2, and the major longline fisheries of the world are described along with available information on their incidental catches of seabirds in section 3. Demersal and pelagic longlining are treated separately for each region. Technical guidelines in place or recommended to reduce seabird incidental catch are described in detail in section 4.

2. A DESCRIPTION OF LONGLINE FISHING METHODS

2.1 GENERAL DESCRIPTION OF LONGLINE FISHING

Longline fishing is one of the world's major methods of catching fish. Baited longlines are used in all oceans and seas, from small-scale artisanal fishing to modern mechanised longline operations, and large proportions (15-90%) of several of the most important fish resources are caught by longlines (Bjordal & Løkkeborg 1996). Notwithstanding bird mortality (and that of turtles, e.g. Mayol *et al*. 1988, Bolten *et al*. 1996, Kleiber 1998), longlining has commonly been regarded as a comparatively environmentally friendly fishing method, and thus the use of longlines is being encouraged by fisheries management authorities (e.g. Sutterlin *et al*. 1982). The operation of longline gear causes no destructive effects on bottom habitats, discards of undersized and unwanted fish can be comparatively low when compared with some other fishing methods (but see Hinman 1998) and fish of high quality are captured at a low fuel consumption.

Longline is a passive fishing technique, in that it is primarily the swimming activity of the target fish that brings them into contact with the gear, although pelagic longlines do drift in the water. The catching success of baited hooks is based on the target species' demand for food, and fish are caught on longlines because the bait releases odours that are dispersed by the water current. The fish regard the bait as food, and the scent and taste of the bait trigger the fish to search for and ingest the baited hook. Vision presumably also plays a role in bait location. Once the baited hook has been located and ingested, the catching success is determined by the ability of the hook to prevent the fish from escaping.

Longline fishing is a very versatile fishing method that is used from small open boats operating in shallow coastal waters and from large ocean-going vessels operating on high-seas fishing grounds at depths down to 3000 m. The gear can be set throughout the water column, on the seabed (demersal longlining), floated off the bottom at various fishing depths (semipelagic longlining) or suspended from floats drifting freely at the surface (pelagic longlining). In this way longlines can be used to target a great variety of fish species from bottom-dwelling species such as halibut to the highly migratory tunas of the open seas.

Demersal (bottom) longline fishing takes place on the relatively shallow waters of the continental shelves and slopes of all continents, around some oceanic islands, and over sea mounts. Some demersal longline fisheries are artisanal in nature, taking place from small, sometimes open, vessels. Others are commercial, taking place from large deep-water vessels which process their catch aboard. Many demersal longline fisheries take place in cold, upwelling waters at relatively high latitudes. These are commonly regions where large numbers of seabirds are present, allowing scope for interactions and incidental mortality to occur.

Pelagic (surface) longline fishing takes place in deep water generally off continental shelves. Most, but not all, pelagic longlining is commercial in nature. Pelagic longlining concentrates on tuna and billfish species and is operated widely from temperate to tropical waters in all oceans. Species targeted by pelagic longlining include northern bluefin tuna *Thunnus thynnus*, southern bluefin tuna *T. maccoyii*, bigeye tuna *T. obesus*, yellowfin tuna *T. albacares*, albacore *T. alalunga* and broadbill swordfish *Xiphias gladius*. Sharks, marlins, sailfish and spearfish (family Istiophoridae) and tuna-related species (Family Scombridae) may form a significant part of the directed catch or bycatch in some regions.

Longline fishing is regarded to be a species- and size selective fishing technique and this property may mainly be attributed to the versatility of the longline gear both in construction and way of operation. Longlining can take advantages of species-specific habitat preferences by setting the baited lines over selected fishing grounds or at specific depths. Fish of different sizes often show different habitat preferences, and the fishing operation may thus be targeted on larger fish.

The distribution of tuna species in the water column is influenced by their preferred temperature. Bigeye tuna, which is distributed deeper than other tunas, is caught by using a 'deep longline' developed to target the species (Suzuki *et al*. 1977, Yang & Gong 1988, Gong *et al*. 1989). Another example of how species selectivity in longlining may be effected by gear characteristics is the choice of bait type. Because feeding stimulants have been shown to be species specific (Carr 1982, Mackie 1982, Carr & Derby 1986), fishing experiments testing various bait types have demonstrated the effect of bait type on species compositions of longline catches (Martin & McCracken 1954, Imai 1972, Imai & Shirakawa 1972).

Bait size is an important gear parameter affecting the size of fish caught by longlines (McCracken 1963, Johannessen 1983, Løkkeborg 1990), whereas the effect of hook size on size selectivity has been less clearly demonstrated (Ralston 1982, Løkkeborg & Bjordal 1992). Species and size selectivity in longline fishing has been reviewed by Løkkeborg & Bjordal (1992).

2.2 DESCRIPTION OF GEAR CONFIGURATION AND OPERATION

All longline gear used in the world-wide fishery is based on a basic unit, consisting of four parts: the mainline (groundline), the snood (gangion or branch line), the hook and the bait (Fig. 1). The mainline, which varies in length according to the type of fishing, is rigged with a certain number of hooks off the branch line. Variations are found in terms of type, length and dimension of snood and mainline, type of hook and bait, in the way the snood is attached to the mainline, and in the presence and amounts of weights attached to the line. There are also great variations in setting and hauling devices, and in the way the gear is operated. A detailed description of longline gear construction and operation is provided in Bjordal & Løkkeborg (1996).

Polyamide (nylon) and polyester are the most common materials used for snood and mainline. Both multifilament and monofilament lines are used, the former is used for demersal longlining for groundfish due to its high breaking strength and resistance to chafing, whereas the latter is preferred for pelagic and semipelagic longlining for tuna and related species because the catching performance of monofilament lines has been shown to be superior to that of multifilament ones.

The snood may be attached to the mainline in one of three ways. Traditionally, snoods have been tied to the mainline, but more recently snap fasteners and swivels have replaced traditional snood attachment in several longline fisheries. Snap fasteners are commonly used

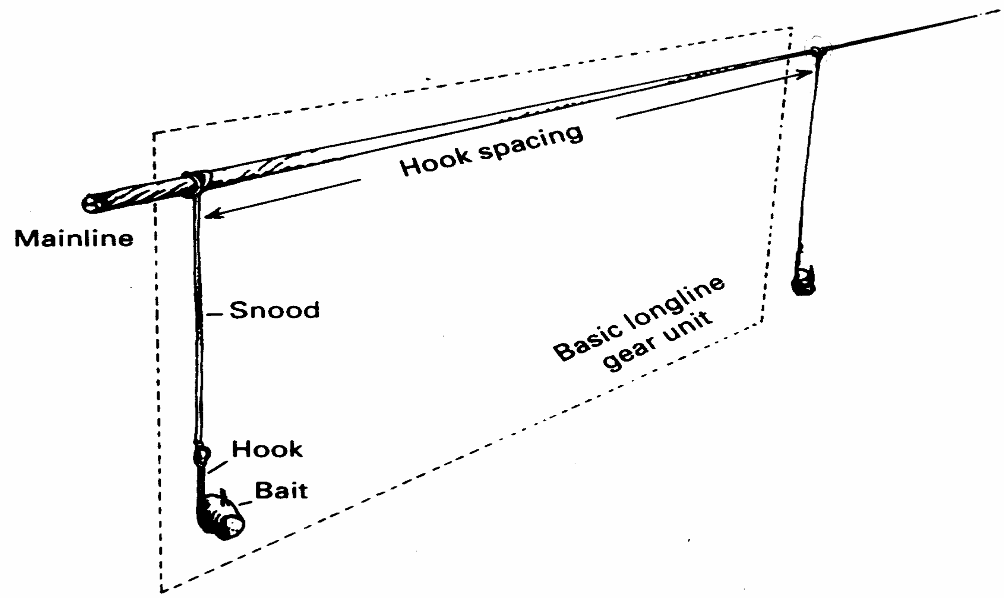


Figure 1. The basic unit of longline gear: mainline, snood hook and bait. Redrawn from Bjordal &Lokkeborg (1996)

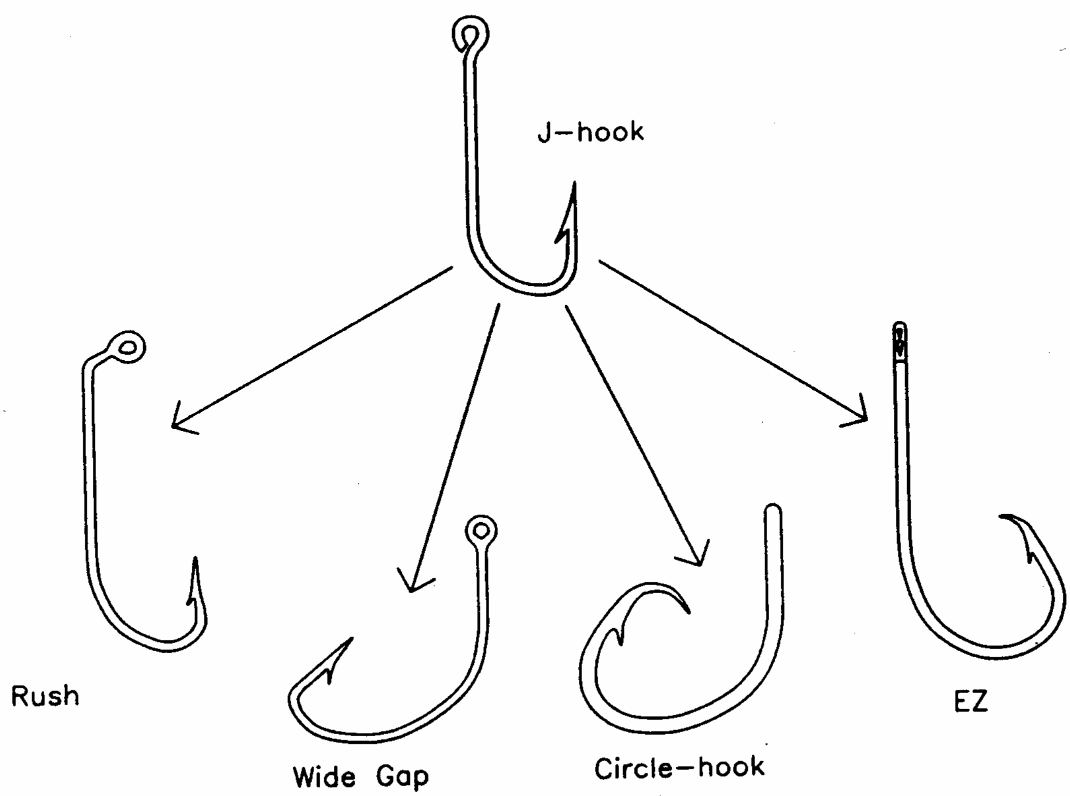


Figure 2. Development of new hook designs showing the traditional J-hook and the more effective new hook types (Redrawn from Bjordal & Lokkeborg (1996)

in longlining for tuna and Pacific Halibut *Hippoglossus stenolepis*, and swivels in fisheries for various demersal species.

Until recently the traditional J-shaped hook was most commonly used for longlining. Fishing experiments have shown that considerable increases in catch rates can be obtained by using improved hook designs. These new hook types have entirely replaced the traditional J-hook in several longline fisheries (Fig. 2). The circle hook is used in tuna longlining and in the fisheries for demersal species in the northeastern Pacific and northwestern Atlantic Oceans. The EZ-baiter hook is commonly used in the fishery for demersal fish in the northeastern Atlantic Ocean.

Longlines are baited either manually by hand or mechanically by baiting machines. Hand baiting is predominant and on small vessels is done onshore, whereas on larger vessels baiting is undertaken at sea. However, an increasing number of larger longline vessels ("autoliners") targeting demersal species use automatic baiting machines. The high-sea fishing fleet in the northeastern Atlantic Ocean is dominated by autoliners which also are common in the longline fishery in the northeastern Pacific Ocean and in the fishery for Patagonian Toothfish *Dissostichus eleginoides* in the Southern Ocean.

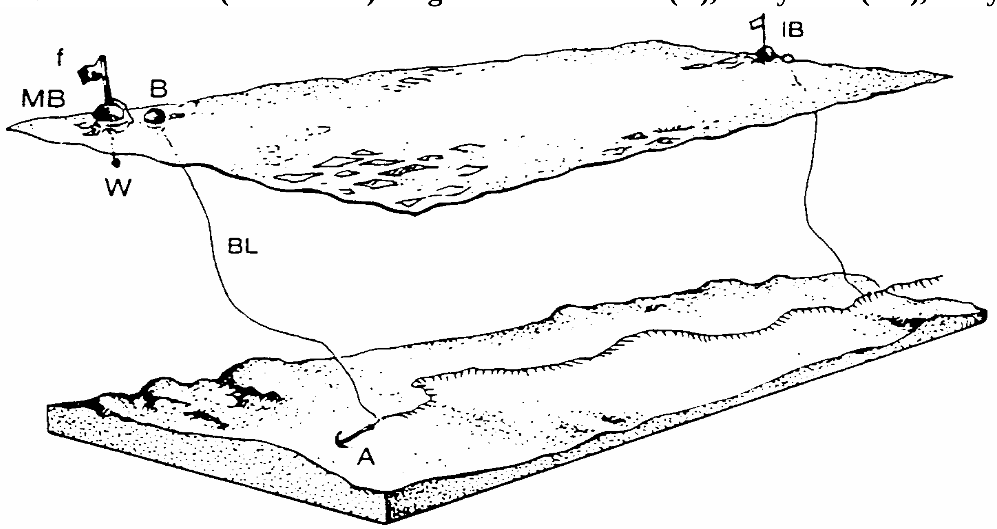
Longlines are usually set from the stern, and during this part of the longline catching cycle, the baited hooks are available to foraging seabirds. During setting, the baited hooks remain at or near the surface for a short while before they start sinking, and seabirds feeding on baits may occasionally become hooked. The distance over which the longline is floating during setting varies with gear configuration and way of setting, but might be as long as 100 m or more. In demersal longlining, this distance is shorter for longlines baited by hand and set from tubs than for longlines set from autoliners. When longlines are set from tubs, the tension on the line is low and weights are normally used to increase the sinking speed, making it more difficult for birds to take baits. In mechanized longlining, hooks are pulled through the baiting machine where they briefly become snagged as they are automatically baited. This process cause additional tension on the line and line sinking is delayed. The sinking speed in mechanized bottom longlining has been measured as 13 cm s^{-1} (Engås & Løkkeborg 1994). In tuna longlining, a line shooter is used and the lines can therefore be set slack with no tension. During the first several minutes after setting tuna longlines, the sinking speed of the hooks ranged from 20 to 40 cm s^{-1} (M. Okazaki unpubl. data). A line shooter is currently being developed for mechanized demersal longline operation, and may prove to increase sinking speed.

The time of day when longlines preferably are set varies between and within the various longline fisheries, and setting time is another important factor of longline operation that may affect the availability of baited hooks to seabirds. Because several fish species exhibit diel rhythms in feeding activity with an increase in activity at dawn (Fernö *et al*. 1986, Løkkeborg *et al*. 1989, Løkkeborg & Fernö in press), setting times affect longline catch rates (Løkkeborg & Pina 1997). Thus fishers, particularly when targeting demersal species, often set their lines before sunrise. This means that the lines are set in darkness, and night setting has been proposed as a simple solution to reduce the incidental catch of seabirds (Brothers 1991). However, in longlining for tunas which are visual feeders (Atema 1980), the lines are often set under light conditions that allow birds to take baits.

There are three main methods of setting longlines although there are different variants of each method. Bottom set longlines (demersal longlining) are most common and used by fishers targeting demersal species. The baited lines are set on the sea bed with an anchor, buoy line, buoy and marker buoy at either end (Fig. 3). Semi-pelagic longlines are anchored to the sea bed like bottom set longlines, but the mainline is floated off the bottom at variable fishing depths in accordance with the vertical distribution of the target species (Fig. 4). This setting method is used to target hake *Merluccius* spp., and is also used seasonally for other demersal species that show a semi-pelagic distribution at specific time periods. Pelagic longlines are the third setting method, in tuna longlining. The baited longlines are suspended from surface floats and drift freely in the sea (Fig. 5).

Fishers are aware that seabirds taking bait during line setting both cause incidental mortality and affect longline catchability and profitability, and they therefore take action to reduce this problem. In the demersal longline fisheries in the North Atlantic and North Pacific, fishers traditionally use a scaring device to prevent seabirds from taking bait. This device is a line with floats attached to its end, and the line is towed during setting with the floats moving in the area where birds may take bait. Preliminary results of an ongoing scientific study have shown that the device reduces seabird catches significantly.

Figure 3. Demersal (bottom-set) longline with anchor (A), buoy line (BL), bouys (B)



marker buoys (MB) with weights (W) and pole and flag (f). Redrawn after Bjordal & Løkkeborg 1996)

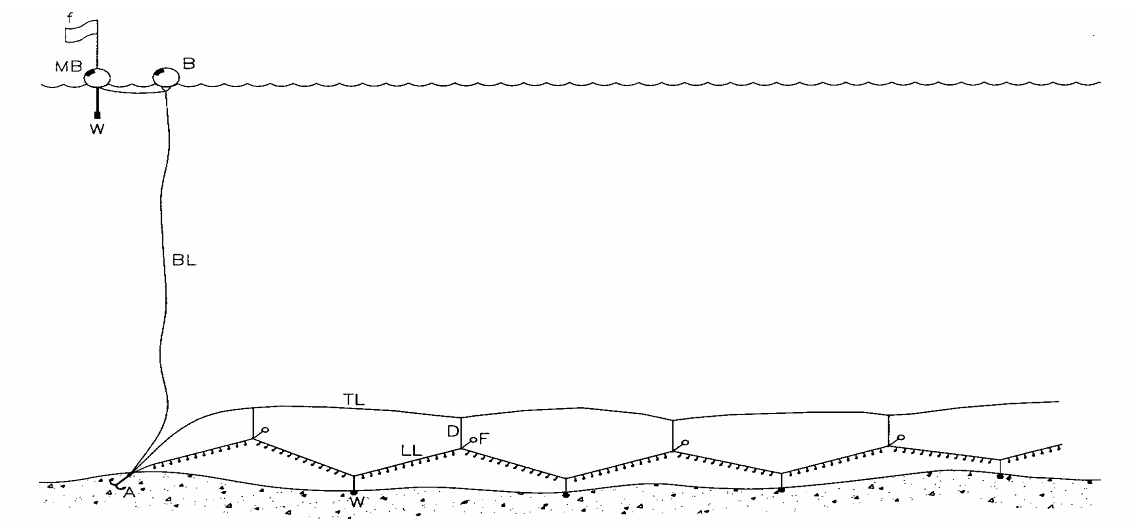


Figure 4 **Semipelagic longline with anchor (A), buoy line (BL), buoys (B), marker buoy (MB), with weight (W), pole and flag (f), longline (LL), float (F), dropper (D) and topline (TL)**

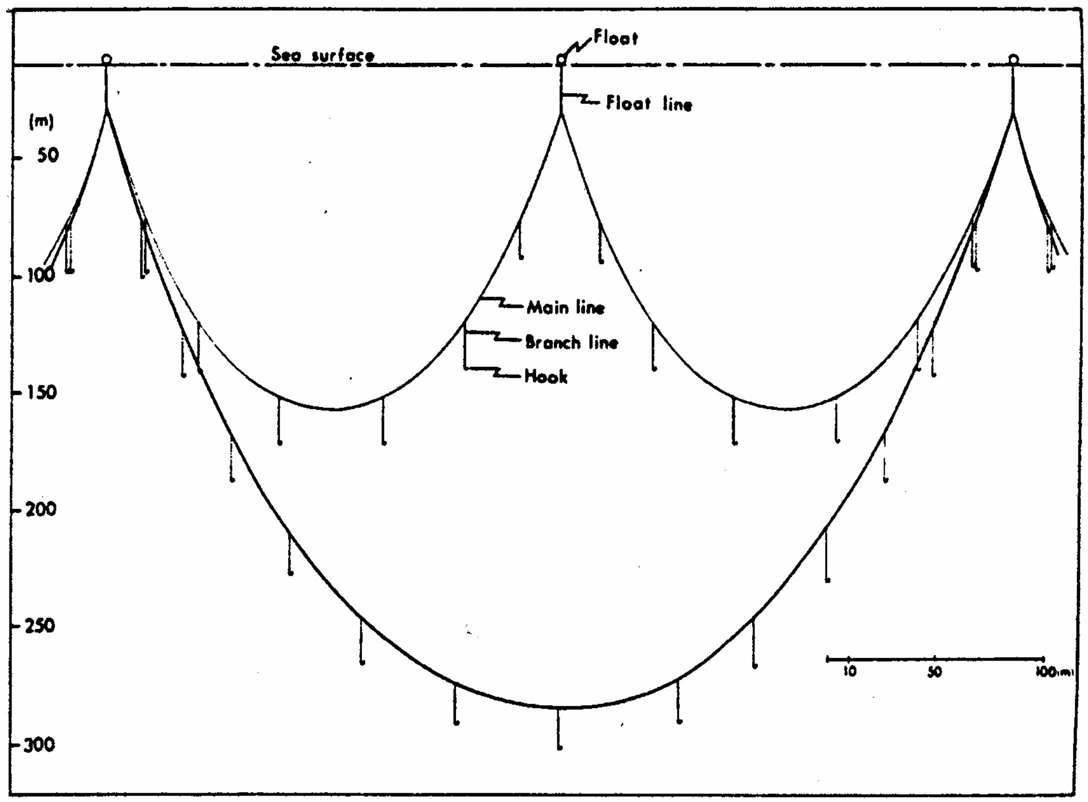


Figure 5. Pelagic longlines showing the shape of regular tuna longline with 6 branch lines between the floats (above) and deep tuna longline with 13 branch lines between the floats (below). Redrawn from Suzuki *et al* (1977)

3. DESCRIPTION OF THE WORLD'S MAJOR LONGLINE FISHERIES AND THEIR INCIDENTAL CATCHES OF SEABIRDS

On a global scale there is a great variety of longline fishing methods, and it would be difficult to make a comprehensive description that includes all longline fisheries of the World. This section provides an overview of the most important fisheries and to cover the major regions fished by longlines (Table 1). For each fishery, vessels, gear and fishing method are described, and catch and effort statistics are given. A standardised presentation of the information was aimed at, but was found difficult because data collected by the various national management bodies come in different formats.

Table 1. Regions, main target species and fishing methods of the world's major longline fisheries

Area	Main target species	Longline fishing method
Northeastern Atlantic	Cod, haddock, tusk, ling, wolffish	Demersal
Northwestern Atlantic	Cod, hake, haddock	Demersal
Northeastern Pacific	Cod, halibut, sablefish	Demersal
Northwestern Pacific	Walleye pollock, cod	Demersal

South America	Hake, kingklip, Patagonian toothfish	Demersal
Southern Africa	Hake, kingklip	Semipelagic
Australasia	Kingklip (“Ling”), Snapper, Trevalla	Demersal
Southern Ocean	Patagonian Toothfish	Demersal
All oceans	Tuna and allied species, swordfish, sharks	Pelagic

3.1 NORTHEASTERN ATLANTIC OCEAN AND MEDITERRANEAN SEA DEMERSAL LONGLINE FISHERIES

The Fishery

Most longlining in the northeastern Atlantic Ocean is for demersal species, although Japanese longliners have from 1994 fished as far north as the Faeroes and Iceland for tuna (ICCAT 1997, B. Olson pers. comm. to E. Dunn.). Longline vessels in the northeast Atlantic region operate both on coastal and high-sea fishing grounds, moving seasonally between fishing grounds targeting different species (Dunn 1994, Fig. 6). In the Mediterranean Sea both demersal and pelagic longlining takes place. Demersal longlining is undertaken by Norway, Iceland, the Faeroes, Ireland, the United Kingdom, France, Spain and Portugal (including the Azores Archipelago and Madeira). The Norwegian, Icelandic and Faeroese fleets dominate the industry, catching Atlantic cod *Gadus morhua*, haddock *Melanogrammus aeglefinus*, tusk *Brosme brosme*, ling *Molva molva*, blue ling *M. dipterigya*, Atlantic halibut *Hippoglossus hippoglossus*, wolffish *Anarhichas lupus*, redfish *Sebastes mentella* and sharks on the shelf and shelf edge to the north of the United Kingdom (P. Large *in litt.* to E. Dunn). UK longliners (mainly small and inshore) target cod and ling, as well as elasmobranch fish species (spiny dogfish and rays) (Dunn 1994, Camphuysen *et al.* 1995).

The Norwegian longline fleet was made up of 813 vessels in 1996, excluding vessels
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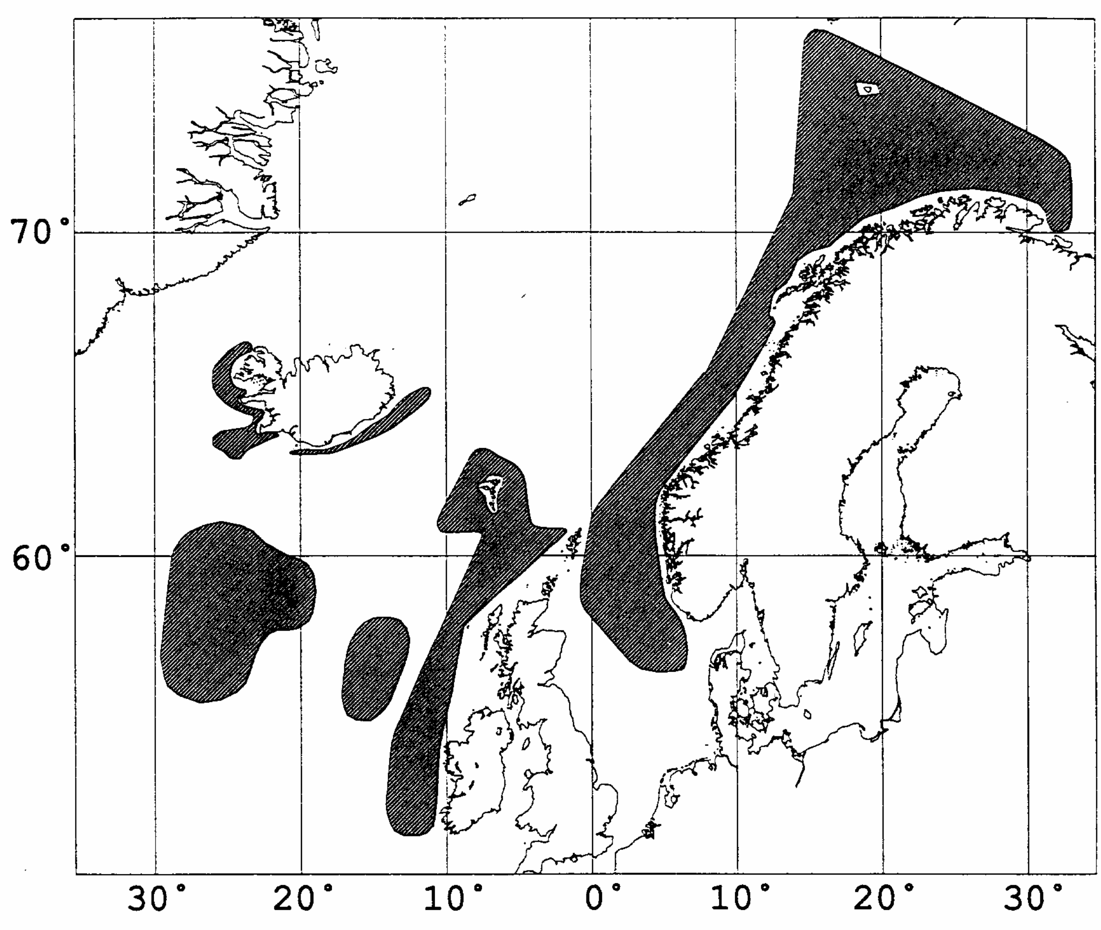

Figure 6. The main fishing grounds operated by longline vessels in the northeastern Atlantic Ocean

Table 2. Annual longline landings (tonnes) of groundfish in Norway and Iceland in 1996

Country	Cod	Haddock	Tusk	Ling	Wolffish	Greenland halibut	Total
Norway	63897	29670	17564	14497	5829	6151	144146
Iceland	38967	7524	4933	1393	11083	2447	69018

The fishery authorities in Iceland and Norway occasionally send observers onboard fishing vessels to inspect logbooks and catch compositions (size and species). This inspection is conducted to assess whether total catches and proportions of undersized fish and bycatch species are in accordance with legislation. Because there are no regulations in this region for seabird catch reduction, the observers do not record seabird catches.

Longlining for cod took place in the southern Baltic Sea by Finland, but no longer occurs after the stock collapsed in the early 1980s (M. Hario *in litt.*). Artisanal longlining from small boats for cod took place in the Barents and White Seas by Russia until the 1950s, but was not thought to take seabirds (Bakken & Falk 1998). A Russian autoliner has been fitted out to catch blue catfish in the Barents Sea (Anon. 1997a).

Hake *Merluccius merluccius*, as well as ling and tusk, are caught to the west and south of the United Kingdom by Spanish vessels, some based in Ireland as a joint venture, others fishing under the UK flag (Fahy & Gleeson 1992, Perez *et al.* nd, E. Dunn *in litt.*). From 1991 this fishery concentrated on deep-water sharks, but returned to hake in 1995 (E. Dunn *in litt.*).

Inshore/artisanal longline fisheries by Spain exist for sharks in the Bay of Biscay and for blackspot or red sea bream *Pagellus bogaraveo* in the Gulf of Cadiz (E. Dunn *in litt.*). Small vessel/artisanal fisheries exist off the coast of mainland Portugal for sea breams and other species (Erzini *et al.* 1996), for at least 50 species, including blackspot seabream, by *c.* 45 small vessels around the Azores (Santos *et al.* 1995, G. Menezes pers. comm. to L. Monteiro) and around Madeira for black scabbardfish *Aphanopus carbo* and sharks (Martins & Ferreira 1995, P. Large *in litt.* to E. Dunn).

Small-scale longline fisheries of France and Spain catch hake in the Gulf of Lions in the northwestern Mediterranean (Aldebert & Recasens 1996).

Incidental catch of seabirds

Studies of the relationships between seabirds and fisheries in the Northeastern Atlantic Ocean have concentrated on the utilization of discards from trawl fisheries and incidental takes in nets (Camphuysen *et al.* 1995, Bakken & Falk 1998), and little is known about seabird incidental catch from longline fisheries, with practically no quantitative information available. Lack of regulations, mitigatory measures or observer programmes specifically related to seabird mortality are noticeable features of longline fisheries in this region, with few exceptions. The following information has been gathered to date, much of it of a preliminary nature from personal contacts.

The longline fisheries of Norway, Iceland and the Faeroes in the North and Norwegian Seas take mainly fulmars as well as gannets, Great Skuas *Catharacta skua* and Glaucous, Great Black-backed, Lesser Black-backed and Herring Gulls *Larus hyperboreus*, *L. marinus*, *L. fuscus* and *L. argentatus* (Follestad & Strann 1991, Follestad & Runde 1995, Bakken & Falk 1998, Løkkeborg 1998). Information from the Faeroes and Iceland is non-quantitative and largely based on the recovery of small numbers of banded birds, although it is considered large numbers of fulmars are taken by both nations' longline fleets (Bakken & Falk 1998, A. Petersen *in litt.*, B. Olsen pers. comm. to E. Dunn).

The only quantitative information, and that limited, comes from the Norwegian longline fishery. Longliners losing 70% of their bait to birds during setting has been reported (Løkkeborg 1998). Experimental longlines set without mitigation measures in May 1996 caught 99 birds, the great majority (95%) fulmars, at a rate of 1.75 birds/1000 hooks set (Løkkeborg 1998, see also Løkkeborg & Bjordal 1992). Use of a bird-scaring line reduced mortality to 0.04 birds/1000 hooks (two birds killed). Underwater-setting through a funnel gave a mortality rate of 0.49 birds/ 1000 hooks (28 birds killed) (Løkkeborg 1998). One vessel with an observer aboard caught a reported 10 fulmars in October 1997, during the boreal autumn, giving a far lower take of 0.02 birds/1000 hooks set. No other seabird species was taken on this fishing trip. Take in summer is thought to be several times higher than in winter (Løkkeborg 1998, C. Steel *in litt*.). The whole Norwegian fishing fleet (813 vessels, of which 61 autoliners set *c*. 476 million hooks in 1996) may thus kill a large number of fulmars a year, to which would need to be added the takes of the Faeroese (240 vessels in 1997) and Icelandic (805 vessels setting 230 million hooks in 1996) longline fleets (A. Petersen *in litt.*, B. Olsen pers. comm. to E. Dunn).

Divers or loons *Gavia* spp. have been reported as being entangled in small numbers in fishing gear, including longlines, in the past in the Baltic Sea (Bakken & Falk 1998, M. Hario *in litt.*).

The Spanish longline fishery for hake catches few birds, according to Perez *et al.* (nd) who reported only two fulmars and one Manx Shearwater *Puffinus puffinus* taken during 1994. Whereas these numbers are most likely to be under-representations (E. Dunn *in litt.*) they certainly reflect the paucity of fulmars in waters south-west and south of the United Kingdom where the Spanish fishery concentrates, when compared to farther north (Stone *et al.* 1995, M.L. Tasker *in litt.*).

Little information on seabird bycatch is currently available for the artisanal/inshore fisheries of France, Spain and Portugal in the northeast Atlantic Ocean and the Mediterranean Sea. North Atlantic Gannets have been caught by longliners in Portuguese waters (A. Texeira in Dunn 1994). A few birds are known to be taken around the Azores. During the four years 1993-1997 150 sets (*c*. 500 000 hooks) by a research vessel caught a presumed Cory's Shearwater *Calonectris diomedea* and three gulls *Larus* sp. (G. Menezes pers. comm. to L. Monteiro). Cory's Shearwaters and Audouin *Larus audouinii* and Yellow-legged *L. cachinnans* Gulls have been killed by longlines set around the Spanish Columbretes Islands in the Mediterranean (Sanchez 1998). J. Mayol (*in litt.*) provisionally estimates that 200-1000 Cory's Shearwaters may be killed annually.

3.2 NORTHWESTERN ATLANTIC OCEAN DEMERSAL LONGLINE FISHERIES

The fishery

Demersal longlining in the northwestern Atlantic Ocean has been conducted by Canada fishing off Nova Scotia, Newfoundland and Labrador and in the Gulf of St. Lawrence from the early 1960s (Fig. 7). Species caught included Atlantic cod, haddock, Greenland halibut *Reinhardtius hippoglossoides*, tusk (or cusk), American plaice *Hippoglossoides platessoides*, saithe *Pollachius virens* and white hake *Urophycis tenuis*, known collectively as "groundfish" (Kenchington *et al.* 1994, Halliday & Clark 1995). The total mean annual landing from 1987 to 1991 was 71 879 tonnes. In 1992 a moratorium on groundfish (primarily for cod) fishing came into force in Canadian Atlantic waters. In 1997 a limited commercial longline fishery for cod commenced around Newfoundland by domestic vessels (Bakken & Falk 1998).

The Canadian longline fleet is dominated by small vessels compared to the Norwegian and Icelandic fleets operating in the northeastern Atlantic. The majority of the Canadian catches are taken in the Nova Scotia area (65%), and 809 vessels were active in this area in 1990 (Kenchington *et al.* 1994). Only 11 of these vessels were above 65 feet in length, and 749 were below 45 feet. The smaller vessels bait their lines onshore by hand. The large vessels (>45 feet) also bait by hand, but stay at sea for several days.

Observers have been deployed in the Canadian demersal longline fishery since 1988. However, coverage levels are low, with less than 5% of the trips covered (i.e. 50-100 trips/year). Information is collected on the fishing vessel, gear and fishing set. Observers record estimates of catch and discard weight for each longline string, and length frequencies are collected routinely. Seabird takes are not currently recorded by all observers.

Longlining off Greenland concentrates on Greenland Halibut in fjords and off the northwestern and southern coasts (Bakken & Falk 1998). The fishery in the fjords is conducted by a domestic fleet of small vessels, whereas Norwegian autoliners operate on the offshore fishing grounds. The catches and fishing effort in the waters around Greenland are, however, negligible compared to the Canadian fishery.

Incidental catch of seabirds

Very little information is available on incidental catches of seabirds. A Canadian observer scheme with a low level of coverage (<5% of trips) in operation from 1988 until the moratorium in 1992 did not regularly record, or identify to species seabirds caught (M. Showell *in litt.* to S. Løkkeborg). Although therefore an under-representation, the *c.* 100 records made might suggest that mortality rates were low. The 1997 Newfoundland fishery is not close to seabird breeding colonies (Bakken & Falk 1998). No information on seabird mortality is currently available for the Greenland longline fishery.

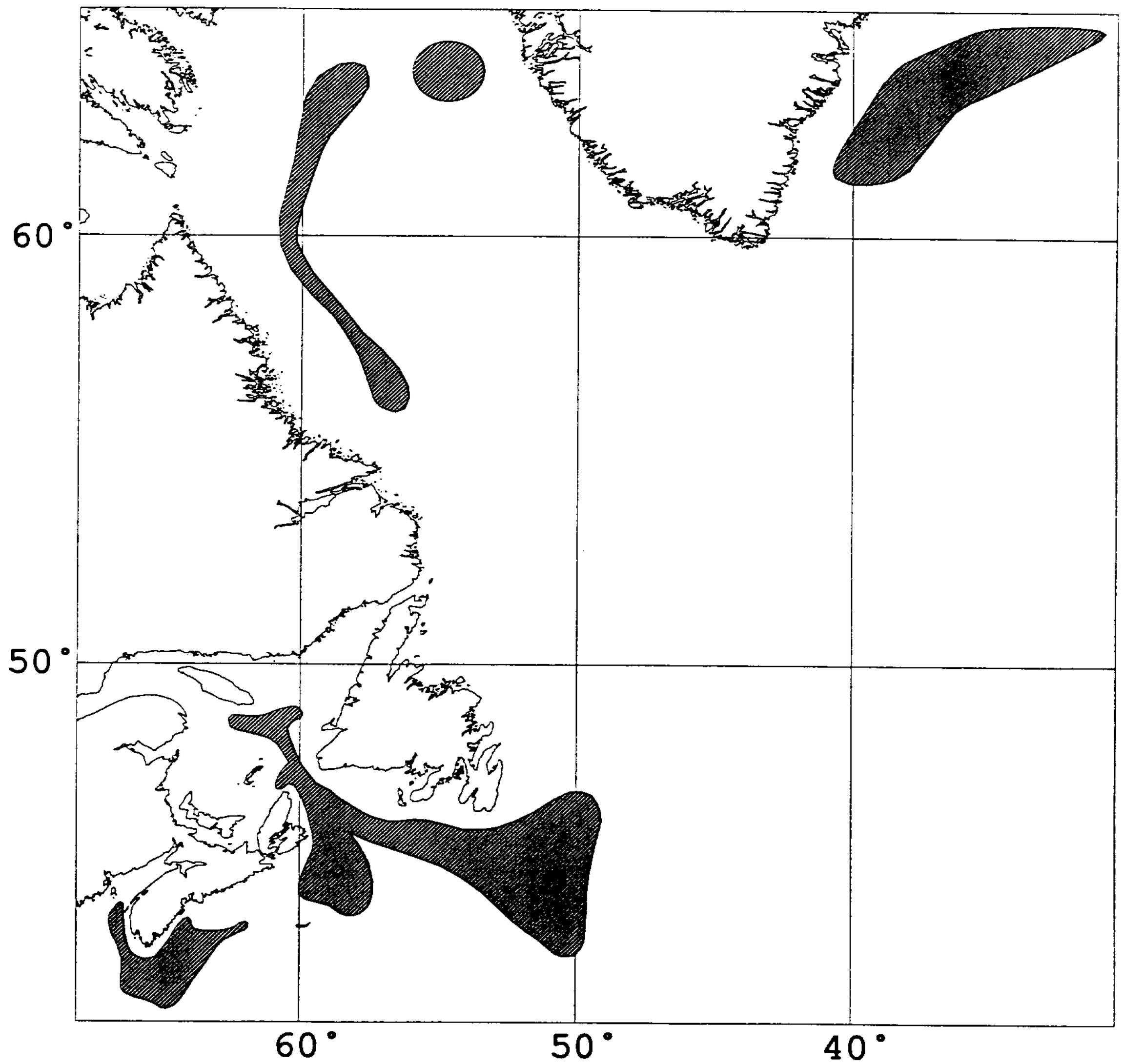

Figure 7. The main fishing grounds operated by longline vessels in the northwestern Atlantic Ocean

3.3 NORTHEASTERN PACIFIC OCEAN DEMERSAL LONGLINE FISHERIES

The fishery

The longline fleet in the northeast Pacific Oceans consists entirely of domestic vessels of the U.S.A. and Canada. This region is divided into three areas, Alaska (Gulf of Alaska and Bering Sea), Canada (British Colombia) and Washington-Oregon-California, from which catch statistics are collected separately. The most important fishing grounds are found in the Alaskan waters, and consequently the fishing activity is much higher in this area (Fig. 8).

Californian longlines target rockfish, sablefish *Anoplopoma fimbria*, and sharks; off Oregon and Washington rockfish, sablefish and spiny dogfish are caught (National Marine Fisheries Service 1995). Off British Columbia longlining takes Pacific halibut *Hippoglossus stenolepis*, redfish *Sebastes marinus* and *Hexagrammus* sp. (International Pacific Halibut

Commission 1996, G. Kaiser *in litt.*). The Bering Sea and Gulf of Alaska groundfish fisheries, managed by the North Pacific Fisheries Management Council of the USA, are large with up to two million tonnes taken, mainly of Walleye pollock *Theragra chalcogramma* and Pacific cod *Gadus macrocephalus*, as well as sablefish, Greenland turbot *Psetta maximus*, arrowtooth flounder and rockfish (National Marine Fisheries Service 1997a, Bakken & Falk 1998). This figure does not include the Pacific halibut longline fishery, which has been managed separately since 1923 by the International Pacific Halibut Commission of Canada and the USA (McCaughran & Hoag 1992). Pacific halibut is fished from northern California, USA to the Bering Sea (International Pacific Halibut Commission 1996).

The vessels range in size from small boats in the several metre range to vessels of 70 m. The larger vessels are operating in Alaskan waters, whereas relatively small vessels fish off Canada and Washington-Oregon-California. Several of the Alaskan vessels targeting Pacific cod and sablefish have automatic baiting systems. A total of 2646 vessels was registered and 15 million hooks were set in the Pacific Halibut fishery in 1996. Of these 2145 were based in Alaska. In the Alaskan longline fishery for other groundfish species, 1281 vessels participated and 201 million hooks were set. Some of these vessels were registered also in the Pacific halibut fishery. About 500 vessels are licensed in Canada (excluding vessels with a halibut license). In the Washington-Oregon-California area, 173 vessel with longline permits landed groundfish in 1996. In addition, non-permit vessels can participate in the longline fishery in this area. Although 1316 vessels were registered in this group, they landed only about 40% of the groundfish catches.

The Pacific halibut fishery was open access until the 1990s when an individual vessel quota system was put into effect in Alaskan and Canadian waters (in 1995 and 1991, respectively). As a result of individual quota programmes, the fishing activity in this region changed. Numbers of active vessels declined, and the halibut fishery now lasts for eight months (mid March to mid November) rather than the one to three days typical of the open-access period.

Also,nearly all halibut fishers baited their longlines onshore when the fishery was open access, but trips now last for several days and longlines are baited at sea. The Washington-Oregon-California portion of the Pacific halibut fishery has remained open access.

Alaskan fisheries dominate the harvest and account for all the Pacific cod landings and approximately 80% of the Pacific halibut landings (Table 3). Canadian landings represent most of the remaining halibut harvest, with small catches taken in the Washington-Oregon-California area. In total, 29 400 tonnes (US$ 105 million) of halibut were landed (mean annual catches, 1994-1996). In the Alaskan fisheries for other demersal species, 149 300 tonnes (US$ 140 million, excluding the value of species reported as “other” in Table 3) were landed. The total catches of groundfish (excluding halibut) taken off British Columbia, Canada and Washington-Oregon-California in 1996 were 7 908 tonnes (US$ 13 million) and 6 611 tonnes (US$ 17 million), respectively.

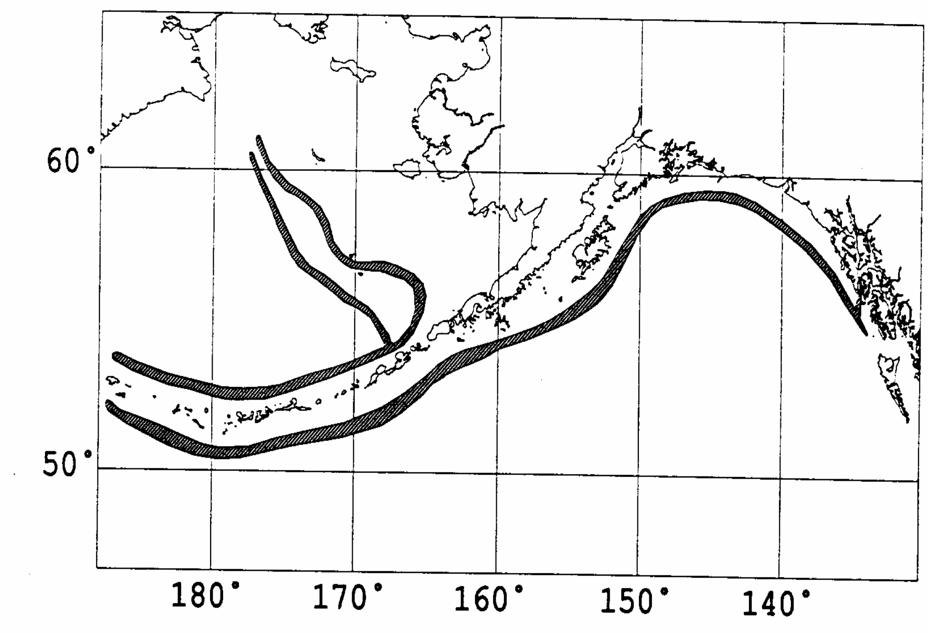

Figure 8. **The main fishing grounds operated by longline vessels in the northeastern Pacific Ocean**

Table 3. Annual longline landings (tonnes) of groundfish in Northeast Pacific by areas. (Landings in Canada and Washington/Oregon/California (WOC) except for Pacific halibut, are given for 1996, all other landings are means for 1994-1996)

Area	Pacific Cod	Pacific Halibut	Sablefish	Greenland Halibut	Rockfish	Other
Alaska	104300	23361	19800	4300	2800	18100
Canada	-	5864	498	-	1628	5782
WOC	-	194	2554	-	2797	1260

U.S. Federal regulations require onboard observers for the groundfish fisheries off Alaska, but not onboard vessels fishing for Pacific halibut unless they also land groundfish. Vessels longer than 38 m require an onboard observer 100% of the time, vessels from 18.3-38 m require an observer onboard 30% of the time and smaller vessels carry observers only when requested. Most halibut vessels fall into the unobserved and 30% categories. Seabird catches are recorded by the observers. No observers are required on longliners fishing in the Canadian and Washington-Oregon-California areas.

Incidental catch of seabirds

No information is to hand on any seabirds killed by longline fisheries off the coasts of California, Oregon or Washington. Apparently, few birds are killed by the British Columbian longline fisheries: two records of Black-footed Albatrosses *Phoebastria nigripes*, one banded, are known (A.E. Burger *in litt*., J. Kaiser *in litt.*) The Canadian Wildlife Service intends studying longlining mortality of seabirds off British Columbia (K.H. Morgan *in litt.*).

The longline fisheries for groundfish (excluding the separately managed Pacific halibut fishery) in the Gulf of Alaska and Bering Sea are known to kill large numbers of birds, and relative to nearly all other demersal longline fisheries, incidental mortality has been well studied. Between 1989 and 1993 Bakken & Falk (1998) estimated annual mortality as 8670 birds (7250 in the Bering Sea, 1420 in the Gulf of Alaska). Interest existed due to the very large numbers of seabirds, especially albatrosses and shearwaters, which were killed by high-seas drift nets in the north Pacific in the 1980s and until the 1992 moratorium (e.g. Johnson *et al.* 1993). The IUCN Vulnerable status (Croxall & Gales in press) of the rare Short-tailed Albatross *Phoebastria albatrus* (Sherburne 1993) also was significant in arousing interest and action (T. Smith *in litt.*).

Table 4. Estimated average annual bycatch of seabirds in the monitored Northeastern Pacific longline fishery, 1993-1996

	REGION		
	Bering sea	Gulf of Alaska	Combined
Catch (tonnes) in observed sets	26.738	3.867	30.603
Total catch (tonnes)	110.633	33.184	143.817
Ratio of catch observed	0,2417	0,1165	0,2128
Rising factor	4,1479	8,5814	4,6994
Observed hooks (in 1000)	29.957	4.315	34.272
Estimated total hook effort	123.959	37.028	160.987
Average observed birds caught	2.620	256	2.876
Birds caught/1000 hooks	0,087	0,059	0,084
Birds caught/tonnes	0,098	0,066	0,093
Estimated annual bycatch of seabirds:			
Northern Fulmar	7.337	1.113	8.450
Gull species	2.381	111	2.492
Shearwaters	530	74	604
Laysan Albatross	527	411	938
Black-footed Albatross	45	493	538
Short-tailed Albatross	1	0	1
Other Species	19	0	19
Total seabird caught	10.840	2.202	13.042

Data on incidental mortality of seabirds are collected by observers and maintained by the National Marine Fisheries Service and the U.S. Fish & Wildlife Service (Bakken & Falk 1998). Observed numbers of seabirds killed are now available from 1989 to 1996 (National Marine Fisheries Service 1995, 1997a,b, R. Stehn *in litt.* to K. Wohl). Numbers of observed mortalities varied from six (in 1989, when there were only 78 days of observations) to an estimated 10 000 in 1991 (4721 days' observation). More birds were observed killed in the Bering Sea/Aleutian Islands region than in the Bering Sea (Table 4). In 1993-1996 an average of 2876 birds was observed killed annually at an overall rate of 0.08 birds/1000 hooks set (Bering Sea 0.09 birds/1000 hooks and Gulf of Alaska 0.06/1000 hooks) (R. Stehn *in litt.* to K. Wohl). The form of the information obtained to date does not allow an analysis of changes in this rate over the time period of observations.

Based on the sizes of the groundfish fisheries, R. Stehn (*in litt.* to K. Wohl) has estimated the numbers of seabirds killed annually over the period 1993-1996 as 13 042, higher than the annual estimate of 8670 birds over the overlapping period 1989-1993 (Wohl *et al.* 1995, National Marine Fisheries Service 1997a). The Northern Fulmar was the species most commonly taken during 1993-1996, followed by gulls *Larus* sp. (including Glaucous-winged *L. glaucescens* and Herring Gulls and Blacklegged Kittiwakes; National Marine Fisheries Service 1997c), Laysan Albatrosses *Phoebastria immutabilis* and shearwaters *Puffinus* spp. (Table 4). Species taken in the Bering Sea region only were unidentified guillemots or murres and auklets (Alcidae) in small numbers (National Marine Fisheries Service 1995). In the period 1983 to 1996 five Short-tailed Albatrosses, all banded juveniles of known age, are known to have been taken by North Pacific groundfish longliners, including from the Pacific Halibut fishery (Cochrane & Starfield 1997, Mendenhall & Fadely 1997, National Marine Fisheries Service 1997a,b).

No quantitative information is available on seabird mortality from the important Pacific halibut fishery of Canada and the USA (Wohl *et al.* 1995, National Marine Fisheries Service 1997b). It is known that birds have been killed, including at least one Short-tailed Albatross in October 1987 (Mendenhall & Fadely 1997, National Marine Fisheries Service 1997a,b), presumably including most of the species killed by the North Pacific groundfish fisheries.

In 1985 the Japanese longline fishery for sablefish resulted in seabird mortalities. Ogi (1995) studied 38 Laysan Albatrosses and six Blackfooted Albatrosses killed by this fishery.

3.4 NORTHWESTERN PACIFIC OCEAN DEMERSAL LONGLINE FISHERIES

The fishery

Demersal longlining in the northwestern Pacific Ocean is primarily conducted by vessels from China, Japan, the Republic of Korea, Russia and Taiwan Province of China. Catch statistics have, however, only been obtained from Japan. Japanese longliners operate on coastal and high-sea fishing grounds around Japan. Both demersal and pelagic longlines are used in this fishery which is classified into three categories, coastal, offshore and high-seas. This fishery is dominated by small boats operating on coastal fishing grounds. A total number of 11 952 vessels was registered in 1995. Of these, 9887 boats were smaller than 5 GRT, 1972 boats were between 5-20 GRT, and 93 were larger than 20 GRT. No observers are required on longliners fishing within the Japanese EEZ.

The total annual landings in 1995 were 64 673 tonnes, with 38 813 tonnes taken in the coastal fishery, 19 448 tonnes in the offshore fishery and 6412 tonnes in the high seas fishery. The most important species are Walleye pollock (16 095 tonnes), Pacific cod (12 279 tonnes) and Pacific halibut (K. Miyauchi in litt.).

Ribbon fish *Trichiurus lepturus* is also taken by longline off Japan (Munekiyo & Ikuta 1985. In 1985 Japan longlined for sablefish in Alaskan waters (Ogi 1995). A commercial-scale fishery for escolar *Lepidocybium flavobrunneum* existed between 1978 and 1980 off the Pacific coast of Japan (Nishikawa & Warashina 1988).

Russia longlines for Pacific cod and Pacific halibut in the northwest Pacific Ocean, particularly off the Kamchatka Peninsula (Dunn 1995, Anon. 1997a). Some vessels have automatic baiting machines (Anon. 1997a).

Artisanal longlining takes place for croaker (Sciaenidae) in the Gulf of Bengal by Bangladesh (Huq *et al.* 1993). Experimental longlining for sharks has taken place off the west coast of India (George *et al.* 1991). Information on artisanal and demersal longline fisheries still needs to be obtained from countries such as China, Indonesia, the Republic of Korea, the Philippines and Taiwan Province of China, as well as for other Asian countries.

Incidental catch of seabirds

No information has yet been found on incidental mortality of seabirds from demersal longline fisheries in the northwestern Pacific Ocean.

3.5 CENTRAL AND SOUTH AMERICAN DEMERSAL LONGLINE FISHERIES

The fishery

Demersal longline fisheries exist in the waters of most if not all Central and South American countries. Available information is summarized by country.

Mexico: Longlining for swordfish takes (Folsom *et al*. 1997, R Phillips *in litt*.). Longlining by Japanese vessels has been reported from the Gulf of California but the type of fishing is unspecified (Everett & Anderson 1991

Venezuela: Longlining takes place for snapper, grouper and sharks (Alio *et al.* 1993, Weidner *et al*. in press).

Brazil: Demersal longlining catches tilefish *Lopholatilus villarii*, namorado or sand perch *Pseudopercis numida* and *P. semifasciata*, groupers *Epinephelus* spp.,. wreck fish *Polyprion americanus* and sharks 150 to 320 km off Sao Paulo and Parana States, southern Brazil (Olmos 1997, Neves & Olmos 1998, Tutui *et al*. ms).

Uruguay: Argentine hake or merluza *Merluccius hubbsi* and rays are caught by longliners of the mouth of the Rio de la Plata (Stagi *et al.* 1998, Weidner *et al*. in press). The fishery commenced in 1994 with one vessel, being joined by a Korean boat in 1995.

Argentina: Demersal longlining in 1995 was undertaken by 19 vessels based in Patagonian harbours on the shelf and shelf break in two distinct areas, between 43°-50°S and 54°-57°S, the southern region comprising 64% of hooks set (Schiavini *et al*. 1998). The northern region on the Patagonian Shelf targets South American kingklip *Genypterus blacodes*, Argentine hake and round skate and commenced in 1992 (Maeda *et al.* 1994, Anon. 1995b, Schiavini *et al.* 1998). The southern region from 1994 has caught Patagonian toothfish *Dissostichus eleginoides* over the shelf break. Argentinian vessels fishing for toothfish within the CCAMLR area are considered separately below.

Chile: A demersal longlining fishery has recently commenced in domestic waters on the continental slope (Spear *et al.* 1995). In southern Chile species longlined include

Patagonian hake *Merluccius australis,* South American kingklip and Patagonian toothfish (Arana *et al.* 1989, R. Schlatter *in litt*.). Chilean vessels fishing for Patagonian toothfish in the CCAMLR area are considered separately in the Southern Ocean Demersal Section below.

Peru, Ecuador and Colombia: Artisanal longlining takes place for sharks and rays (Van Waerebeek *et al.* 1997, D. Weidner *in litt.*). Longlining for sharks has been reported from within the 24-km Galapagos Marine Resources Reserve by up to 80 Japanese, Korean and Taiwanese tuna longliners (Camhi 1995).

Incidental catch of seabirds

The information to hand on incidental catches of seabirds is given by country.

Mexico and Venezuela: no information.

Brazil: A total of 81 seabirds was caught on 19 demersal longline cruises of a research vessel in 1994/95, 160-320 km offshore from 24°-28°S at a rate of nearly 0.3 birds/1000 hooks set (Neves & Olmos 1998). Of the 49 birds identified, six were Yellow-nosed Albatrosses *Thalassarche chlororhynchos*, one Black-browed Albatross *T. melanophrys*, six White-chinned Petrels *Procellaria aequinoctialis*, two Spectacled Petrels *P. conspicillata* and 34 Great Shearwaters *Puffinus gravis* (Neves & Olmos 1998). These are all species commonly observed from demersal longliners in Brazilian waters (Olmos 1997). However, Tutui *et al*. (ms) report 101 birds, mainly Black-browed Albatrosses, White-chinned Petrels and Great Shearwaters but also seven Cory's Shearwaters, killed by the same research longliner in 1994/95 (0.30 birds/1000 hooks). Up to 10 commercial vessels, which do not practice any mitigation measures, are known to have killed seabirds (including black-browed albatrosses and white-chinned petrels) in 1996 and 1997 (G. Bastos *in litt.*).

The Spectacled Petrel is a recently proposed species with a small population at only one breeding locality and an Endangered status (Ryan 1998). More information is critically needed on its current population size to assess the conservation risk from longlining to the species.

Weidner *et al.* (in press) report that Brown Boobies *Sula leucogaster* are occasionally taken on artisanal longlines off northeastern Brazil.

Uruguay: Information is currently only available for incidental mortality of albatrosses, although it is assumed that other species of seabirds have also been killed in demersal longline operations. Two fishing trips in 1995 killed a minimum of 83 Black-browed Albatrosses, at a rate of 0.41 birds/1000 hooks set (calculated from Stagi *et al.*1998).

Argentina: Only anecdotal reports of seabird mortality are so far available, but it would appear mortality is high, with fishing captains reporting up to 50 birds a day being killed (Schiavini *et al.* 1998). Based on mortality rates in the literature, Schiavini *et al.* (1998) roughly estimated that 3832-13 514 birds were killed in the 18-month period in 1993 to 1995 in the Argentinean demersal fishery on the Patagonian Shelf.

Chile: The only information available is of six birds (one Royal Albatross *Diomedea epomophora* , one Black-browed Albatross and four White-chinned Petrels) caught on 1500 hooks (ten sets) from a Patagonian toothfish longliner fishing off Valparaiso at 40°S (R.

Schlatter *in litt.*). Spear *et al.* (1995) suggest that visiting populations of Buller's *Thalassarche bulleri*, Chatham *T. eremita* and Salvin's *T. salvini* Albatrosses could be impacted.

Peru, Ecuador and Colombia: No information is as yet to hand, other than Gales (1993) who states "there is a developing longline industry in Peru which apparently has a problem with bird bycatch (species unknown)". The coastal waters of these countries are visited by Waved Albatrosses *Phoebastria irrorata* breeding in the Galapagos Islands. This species does not normally approach and scavenge from fishing vessels and has therefore thought not to be at risk from longlining (Anderson *et al.*1998; but see Merlen (1996) and Pacific Ocean Pelagic section below).

3.6 SOUTHERN AFRICAN DEMERSAL LONGLINE FISHERIES

The fishery

Demersal (or semi-pelagic) longlining commenced in South African continental shelf waters (mainly in the southwestern Atlantic Ocean) in 1983, initially targeted at the hakes *Merluccius capensis* and *M. paradoxus* (Japp 1993). Interest soon swung to fishing for the more valuable kingklip *Genypterus capensis* (Badenhorst 1988). The catches of kingklip peaked in 1986 at 8684 tonnes, and the catches of hake reached a peak in 1988 of 5514 tonnes. By 1990 kingklip had been over-exploited by this method and the longline fishery was closed (Walker 1991). In 1994 an experimental longline fishery for hake was started with kingklip being allowed as a bycatch, concentrated on the west and south coasts of the Western Cape Province (Anon. 1996a). This fishery has become a commercial one in 1998, with regulations produced for its management. To date, however, no mitigation measures to reduce bird incidental catch are in force (C.L. Moloney pers. comm.).

The vessels participating in the hake longline fishery range in size from 8 to 30 m, and most are 18-22 m. The Spanish semipelagic longline gear with safety lines (toplines) are used by these vessels (Fig. 5). Catch and effort data for the experimental fishery are given in Table 5, and the main fishing grounds are shown in Figure 9. The observer coverage in the fishery is low as only 12-20 trips per year have observers onboard.

Small-scale demersal longlining for shark also takes place in southern African waters (Japp 1993, M. Kreuse pers. comm.). Longlining for hake and kingklip has taken place in Namibian waters (Adams 1992).

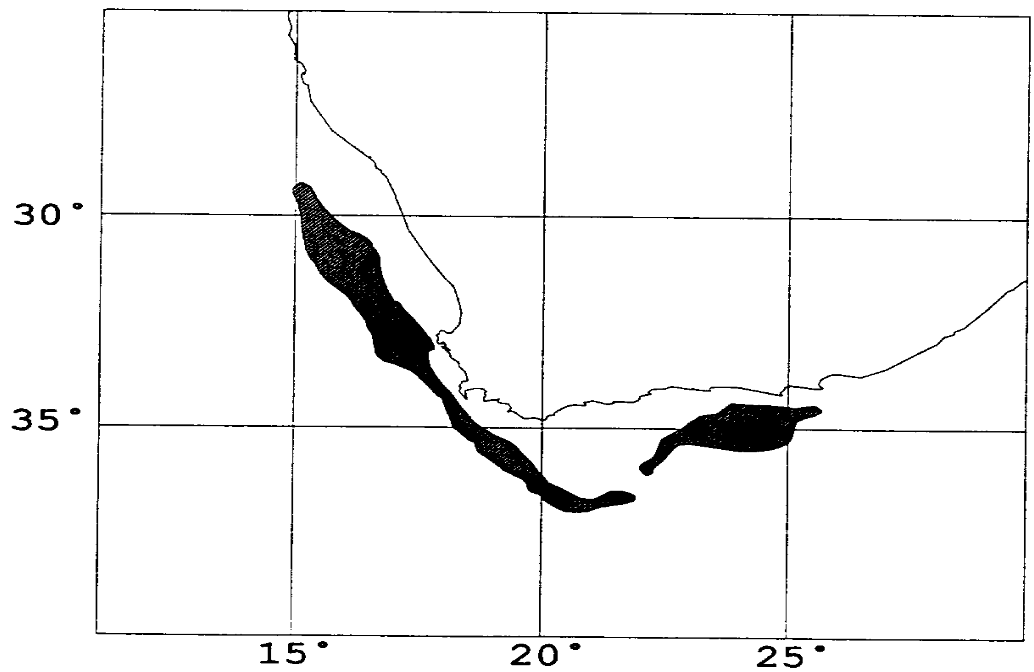

Figure 9. The main fishing grounds operated by longline vessels off southern Africa. Modified after Badenhorst (1988)

Incidental catch of seabirds

Detailed information is only available on incidental catches of seabirds for the South African hake longline fishery of the 1990s. However, it is known that the earlier hake and Kingklip fisheries of the 1980s did result in the incidental mortality of seabirds, with up to 10 (average one to three) White-chinned Petrels as well as albatrosses being taken per set (Ryan & Rose 1989, Adams 1992).

Barnes *et al.* (1997) reported that the only bird species hooked on hake longlines was the White-chinned Petrel. Small numbers of Pintado or Cape Petrels *Daption capense* and Great Shearwaters were reported killed by collisions with gear during hauling. Using 1994 data from both direct observations and fishing logs the annual mortality for the whole fishery was estimated as 8000$\pm$6400 White-chinned Petrels at a rate of 0.44 birds/1000 hooks set. The partial adoption of recommended mitigation measures (Barnes *et al.* 1997) by the fishery subsequently reduced mortality ten-fold to 0.043 White-chinned Petrels per 1000 hooks set in 1996-97 (Ryan & Boix-Hinzen 1997). An estimated 499 birds were killed by 75 vessels setting 11.7 million hooks. Catch rates were greater during the austral winter, reflecting the greater abundance of White-chinned Petrels in South African waters during that season.

No quantitative information is currently available on incidental mortality of seabirds in the South African shark longline fishery. M. Kreuse (pers. comm. to R.M. Wanless) believes no birds are caught because the lines sink immediately on setting.

Unregulated longlining for hake off a newly independent Namibia resulted in the recovery of *c.* 600 hooks in two years' accumulation of guano at a breeding colony of Cape Gannets *Morus capensis* on Ichaboe Island in May 1991 (Williams 1991, Adams 1992). It was thought that the birds had taken discarded heads which still retained the hooks, which were later regurgitated. It is unknown how much mortality occurred, although it was considered a substantial number of gannets must have died at sea.

Table 5. Number of vessels, fishing effort and landings in the South-African experimental longline fishery, 1994-1997. (*Effort is probably underestimated because some vessels did not return their reports, especially in 1994 and 1997).

		Effort*	Landings (tonnes)	
Year	**No. of vessels**	**(1000 hooks)**	**Hake**	**Kingklip**
1994	41	4721	2248	140
1997.	31	2507	1607	113
1996	71	9536	4240	232
1997	68	9337	3784	250

3.7 AUSTRALASIAN DEMERSAL LONGLINE FISHERIES

The fishery

Demersal longlining takes place around New Zealand for snapper *Pagrus auratus* and ling (=South American kingklip) *Genypterus blacodes*, and in Australian waters for snapper, ling, Deep Sea trevalla or Antarctic butterfish *Hyperoglyphe antarctica* and sharks (Otway *et al.* 1996, Anon. 1997b, Alexander *et al.* 1997, Environment Australia 1998). The New Zealand ling fishery is concentrated on the Chatham Rise and around the southern islands. Observer programmes are in place in the New Zealand ling fishery but not yet in the *c.* 200-vessel snapper fishery or in the Australian fisheries (Alexander *et al.* 1997, Brothers *et al.* 1998b, L. Robinson *in litt.*).

Incidental catch of seabirds

Practically nothing is currently known about seabird mortality from the New Zealand snapper longline fishery, although take of *Procellaria* petrels, including the rare Black Petrel *P. parkinsoni*, is expected off New Zealand, according to L. Robinson (*in litt.*). One "large seabird" was reported captured in 1996/97 by this fishery (Anon. 1997b). However, Alexander *et al.* (1997) listed Northern and Southern Giant Petrels *Macronectes halli* and *M. giganteus*, Great-winged Petrels *Pterodroma macroptera*, Sooty Shearwaters *Puffinus griseus*, Flesh-footed Shearwaters *P. carneipes* and Subantarctic Skuas *Catharacta antarctica* as being caught.

The observer programme for the New Zealand ling fishery reported 37 seabirds caught over the four-year period (Anon. 1997b). Preliminary observer data for the 1996/97 fishing year showed that one vessel caught 11 seabirds, including four Critically Endangered

Chatham Albatrosses. Black-browed Albatrosses (*sensu lato*) are also known to be taken by this fishery (Alexander *et al.* 1997). Fishers are obliged to report incidental captures of incidental species: in 1996-97 a total of 93 seabirds (42 as albatrosses or large seabirds, 51 as petrels or small seabirds) was reported. No mitigation measures are currently in force, but some ling vessels use bird-scaring lines (Anon. 1997b).

Little information on the Australian demersal longline fisheries is available although Environment Australia (1998) states that seabird incidental catch has been documented. Brothers *et al*. (1998a,b) reported no seabirds observed killed on voyages that set 57 000 hooks in 1996 and 60 500 hooks in 1997 off north-east Tasmania. The 1996 fishing vessel reported only "a few birds" killed during the setting of three million hooks (Brothers *et al.* 1998a).

3.8 SOUTHERN OCEAN DEMERSAL LONGLINE FISHERIES

The fishery

Longline fishing in the Southern Ocean commenced in the 1988/89 austral summer by the then Soviet Union, directed at Patagonian toothfish *Dissostichus eleginoides* in the area of South Georgia (Dalziell & De Poorter 1993, Croxall & Prince 1996). The species has a circumpolar distribution south of 55°S, being found around many of the islands of the Southern Ocean (Gon & Heemstra 1990). Longlining started around the Kerguelen Islands in 1990/91 (Duhamel *et al.* 1997). Chilean and Bulgarian vessels joined the fishery in 1991/92 (Dalziell & Porter 1993). Fishing is conducted off the southern part of South America (Argentina, Falkland Islands/Maldinas and Chile) and around many of the islands of the Southern Ocean, especially those of the South Atlantic and southern Indian Oceans (South Georgia, South Sandwich, Bouvet, Prince Edward, Crozet and Kerguelen Islands). The fishery is carried out by large mechanized vessels that operate in very deep waters down to 3000 m.

The fishery is regulated by the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) with annual regional quotas set, but in the last two years much unregulated (by non-CCAMLR-flagged vessels) and illegal (by CCAMLR-flagged vessels) fishing has taken place, especially around the Indian Ocean islands (e.g. Album 1997, Anon. 1997c, Lugten 1997, Ryan & Boix-Hinzen 1997, ISOLFICH 1998). The regulated fishery in the CCAMLR Convention area reached a peak in the 1991/92 season at 12 500 tonnes, and 10 250 tonnes for the 1996/97 season (*CCAMLR Statistical Bulletin*, Vol. 9, 1997, CCAMLR 1997). The majority of the regulated catch in the CCAMLR Convention area is landed by vessels from France, Chile and Ukraine. The total reported catch of Patagonian toothfish from the CCAMLR Convention area, and from EEZs outside this area, was 32 991 tons in 1996/97.

Countries that conducted longlining for Patagonian toothfish in 1996/97 included Argentina, Australia, Chile, France, Japan, Korea, Namibia, New Zealand, South Africa, Spain, Ukraine and the U.S.A. Previously, Germany and Russia have longlined for toothfish. In addition, Norway has expressed an interest in commencing fishing in the 1997/98 austral summer season (information supplied by CCAMLR). This list of countries does not include those of unregulated vessels (see ISOLFICH 1998). The unregulated fishery has been estimated at between 107 000 and 115 000 tonnes (*CCAMLR Newsletter* No. 19, December 1997, p.2), about ten times as much as the regulated catch.

CCAMLR collects and analyses data on seabird mortality on an annual basis through its Ad Hoc Working Group on Incidental Mortality arising from Longline Fishing (CCAMLR-IMALF) which first met in 1994 (CCAMLR 1994).

Longlining for Patagonian toothfish also occurs outside the CCAMLR Convention area, in the Falkland Islands/Malvinas "Outer Fishing Zone" and on the Patagonian Shelf by Argentina, Chile and the UK since 1994 (Brothers 1995a, Schiavini *et al.* in press, CCAMLR Secretariat *in litt.*).

Incidental catch of seabirds

The first information on seabird mortality from the Patagonian toothfish longline fishery of the Southern Ocean has come from the finding of albatrosses at their birding sites with attached or nearby regurgitated hooks (e.g. Cooper 1995), as well as from recoveries of banded birds captured by longliners. Many of the hooks found at southern albatross breeding sites (and recovered bands,. Croxall & Prince 1990) have been from tuna fisheries, but the smaller hooks used for toothfish have also been found in the last few years (Cooper 1995, Ryan *et al.* 1997). Among the first direct observations were those of Dalziell & de Poorter (1993) who observed longline hauling by two Soviet vessels in the vicinity of South Georgia in March 1991. They recorded six dead seabirds on three lines: one Black-browed Albatross, four White-chinned Petrels and one unidentified albatross, and calculated catch rate to be *c.* 0.67 birds/1000 hooks. Based on an estimated 5 229 000 hooks set in 1990/91, Dalziell & de Poorter (1993) suggested that as many as 2301 White-chinned Petrels and 1150 albatrosses had been killed by the Patagonian Toothfish longline fishery.

Catch rates have ranged from <0.10 to 0.67 birds/1000 hooks set. Species caught include albatrosses (mainly Grey-headed *Thalassarche chrysostoma* and Yellow-nosed), giant petrels, White-chinned Petrel, Grey Petrel *Procellaria cinerea*, Pintado Petrel and Subantarctic Skua. A few penguins (Gentoo *Pygoscelis papua* and Macaroni *Eudyptes chrysolophus*) have been reported caught alive, thought to have become entangled during line-hauling (Moreno *et al.* 1996, Ryan *et al.* 1997). The White-chinned Petrel has been the most abundantly taken species in several studies in widely separate regions of the Southern Ocean (Cherel *et al.* 1996, Moreno *et al.* 1996, Williams & Capdeville 1996, Ryan *et al.* 1997, Ashford & Croxall 1998). Information exists for a skewed sex ratio, with male Grey-headed and Yellow-nosed Albatrosses and White-chinned Petrels being taken in significantly larger numbers than females around the Prince Edward Islands in the southern Indian Ocean (Ryan & Boix-Hinzen in press). White-chinned Petrels are taken in numbers from night sets (Ashford *et al.* 1995, Ryan *et al.* 1997). Seabird bycatch varied seasonally (higher in the austral summer), with distance from breeding site (highest closest to land) and with time of day (other than White-chinned Petrels fewer caught at night) in one of the most comprehensive analyses undertaken to date (Ryan *et al.* 1997). Importantly, birds taken by the Prince Edward Islands fishery were nearly all adults of breeding age.

A lack of knowledge of the size of the unregulated/illegal fishery, along with no information of the incidental mortality of seabirds it causes makes it difficult to assess the overall effect of the Patagonian Toothfish fishery on seabirds. Ryan *et al.* (1997) point out that the unregulated/illegal fishery is unlikely to have adopted mitigation measures, so its catch rates of seabirds may be assumed to be higher than those recorded in the regulated fishery. However, based on indirect knowledge of the size of the unregulated/illegal fishery from fish landings, Ryan *et al.* (1997) have estimated that overall bird bycatch in the vicinity of the Prince Edward Islands may have been five to 20 times that reported (923 birds) by observers in the regulated fishery, giving a total bycatch of 5000 to 20 000 birds. It was considered that the unregulated/illegal fishery bycatch is at least one order of magnitude higher than that of the regulated fishery in the same areas by the CCAMLR Working Group on Fish Stock Assessment at its 1977 and 1998 meetings (CCAMLR 1997, CCAMLR unpubl. data). Based on information presented to the Working Group in 1997 it can be roughly estimated that up to 145 000 birds were killed by the total (regulated plus unregulated/illegal) Patagonian toothfish fishery during the 1996/97 season.

Based on evidence to hand (see also Alexander *et al* 1997, Ryan *et al.* 1997, Croxall & Gales 1998, Gales 1998) the CCAMLR WG-FSA noted that such levels of incidental catch of birds, representing 1-16% of annual breeding populations of several species of albatrosses, giant petrels and Whitechinned Petrels, were not sustainable and will lead to population decreases, most especially at the sub-Antarctic islands of the southern Indian Ocean (CCAMLR 1997). The affected albatrosses are all regarded as globally threatened or near-threatened (Croxall & Gales 1998).

Outside the CCAMLR Area, Falkland Islands/Islas Malvinas and Patagonian Shelf toothfish fisheries kill primarily Black-browed Albatrosses, with fewer Grey-headed Albatrosses, giant petrels, White-chinned Petrels, Pintado Petrels and Sooty Shearwaters (Brothers 1995a, Cielniaszek & Croxall 1997, Schiavini *et al.* 1998). In 1996/97 the catch rate around the Falklands was 0.34 birds/1000 hooks for a total reported mortality of 103 birds (Cielniaszek & Croxall 1997).

3.9 PELAGIC LONGLINE FISHERIES: AN OVERVIEW

Japan, Taiwan Province of China and the Republic of Korea are the major operators in the tuna longline fisheries. Countries such as Spain, U.S.A., Canada, Portugal, Italy, Greece and Brazil carry out pelagic longline fishery in the Atlantic Ocean and Mediterranean Sea and target mainly Swordfish. Indonesia, Mozambique and Yemen are major countries in the Indian Ocean in addition to the three Asian countries. In the Pacific Ocean, China, Australia, Fiji, New Caledonia, French Polynesia and the U.S.A. carry out pelagic longlining for tuna. The three Asian countries land 79% of the total pelagic longline catches in the Atlantic Ocean, 56% in the Indian Ocean and 83% in the Pacific Ocean (Table 6). These countries land, however, only 23% of the swordfish catches in the Atlantic and 50% in the Pacific Oceans.

The catch and species compositions of the tuna longline fishery by oceans is shown in Fig. 10. Bigeye and yellowfin tunas are major species in the Pacific and Indian Oceans. Bigeye tuna is also an important species in the Atlantic Ocean where swordfish constitutes a relative large proportion of the catches. The catches of Northern and Southern bluefin tunas are relatively small, but the prices of these species in the Japanese sashimi (raw fish) market are substantially higher than for other species. Almost all catches of bluefin and bigeye tunas are exported to the Japanese sashimi market, whereas the catches of albacore are supplied to the European and North American canning industries. Swordfish is mainly consumed in Europe and the U.S.A.

Table 6. The percentages of tuna catches landed by vessels from Japan, Taiwan Province of China and the Republic of Korea by oceans and species (1994)

Ocean	Bigeye	Yellowfin	Albacore	Southern Bluefin	Northern Bluefin	Swordfish	Total
Pacific	90.4	73.7	93.2	44.6	98.0	50.0	83.4
Atlantic	97.3	100.0	100.0	100.0	46.2	23.4	79.0
Indian	72.2	38.6	91.2	65.5	-	69.6	55.6

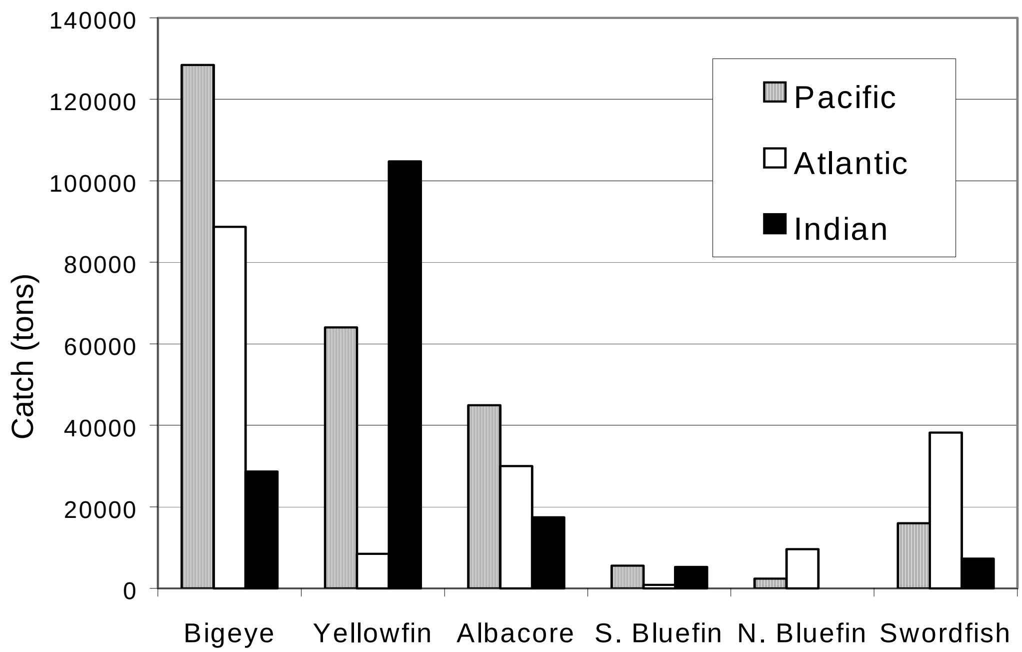

Figure 10. Annual catches (tons) in the global tuna longline fishery by oceans and species (1994)

Japanese tuna longline vessels can be classified into three categories, coastal, offshore and distant water longliners. There are about 700 coastal vessels (10-20 GRT), 200 offshore vessels (20-120 GRT) and 750 distant water vessels (120-500 GRT). The operational area for coastal and offshore vessels is restricted to the northwestern Pacific Ocean by Japanese regulations. The total number of vessels has decreased gradually by about 20% in the recent two decades, and the decrease has been highest for the offshore vessels which has decreased by 40% in this period.

Taiwanese tuna longline vessels can be classified into three types in accordance with the forms of their catch; albacore, deep-frozen sashimi and fresh sashimi longlining. Albacore longlining was once the most important tuna fishery with its peak of over 600 vessels. The fleet size of Albacore longliners in 1997 was 236 vessels, of which 92 operated in the Atlantic Ocean, 66 in the Indian Ocean, 37 in the Pacific Ocean, and 41 shifted to shark

longlining in Indonesian waters. There are 332 longliners operating in the deep frozen sashimi tuna fishery.
The most important fishing ground of this fleet is the Indian Ocean with 213 vessels. There are 108 vessels in the Atlantic Ocean and 11 in the Pacific Ocean. The fleet of longliners that is landing fresh sashimi tuna consists of smaller vessels (60-100 GRT), and currently it is estimated that there are about 150 Taiwanese longliners operating in the southwestern Pacific and Indian Oceans.

The Republic of Korea tuna longline fishery commenced in 1958, and grew rapidly to 589 vessels by 1975. The number of vessels has decreased gradually to 192 vessels in 1997. The great majority of the Korean vessels operates in the Pacific Ocean. The numbers of vessels from China, Indonesia and other countries are increasing, although there is insufficient information for these countries.

The geographical distribution of the global pelagic longlining effort is shown in Figure
11. The data represent average number of hooks deployed each year during 1989-93.

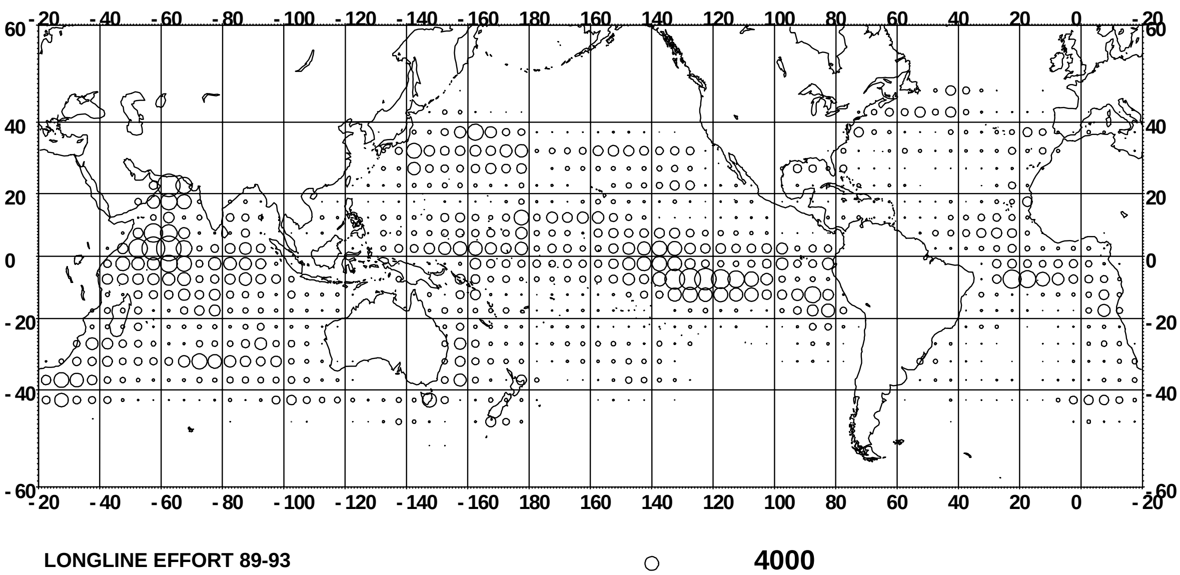

Figure 11. Global longline fishing effort for tuna as average thousands of hooks/year in 1998-93

The mean effort of the Japanese fleet in terms of number of hooks was 481 million hooks per year (1992-1996, not including the coastal fishery); 301 million were set in the Pacific Ocean, 103 million in the Atlantic Ocean and 78 million in the Indian Ocean. The fishing effort of the Taiwanese tuna fleet was 406 million hooks in 1995.

In the Atlantic Ocean, the major fishing grounds are located in the northwest where swordfish and yellowfin, bigeye and Northern bluefin tunas are targeted, and in the central tropical waters where bigeye tuna and swordfish are the main species caught. In the Mediterranean Sea, Northern bluefin tuna and swordfish are targeted by several of the bordering countries. In the Indian Ocean, the most important fishing grounds are found in northern waters where yellowfin and bigeye tunas constitute the main species caught. In the

Pacific Ocean, there are several important fishing grounds (off Japan, northern water off Hawaii, western and eastern tropical waters, Tasmanian Sea) for bigeye, albacore and yellowfin tunas. Southern bluefin tuna is targeted in temperate waters at around 40ºS in all oceans.

The Japanese fleet used to target mainly yellowfin and albacore tunas from the 1950s to mid 1970s to supply the U.S.A. canning industry. The fleet gradually switched to bigeye, Northern and Southern bluefin tunas to supply the Japanese sashimi market. The Republic of Korean and the Taiwanese tuna longline industry also developed in two stages, but the shift from supplying the canning industry to mainly fishing tuna for sashimi occurred later than it did in Japan. The Republic of Korean fleet now mainly targets bigeye tuna for export to Japan. The Taiwanese fleet is currently changing from targeting mainly albacore to bigeye tuna and other highly priced tuna species. This shift was driven by economic and market forces because bigeye and bluefin tuna fetch a higher price than do yellowfin tuna and albacore in the sashimi market. Tuna prices at the sashimi market vary substantially, not only between species, but also within a species, due to the quality of the fish as this market has very stringent quality requirements. The European and North American fleets have traditionally targeted swordfish and there is no significant change in these fisheries.

Accompanying the shift in the most important target species, a ‘deep longline’ to target bigeye tuna was developed in the mid 1970s. Bigeye tuna is distributed deeper in the water column (about 300 m) than are yellowfin tuna and albacore which both occur at a depth shallower than 200 m. The depth of the gear is usually adjusted by changing the number of branch lines (snoods) between two floats (i.e. number of branch lines per basket), as well as the mainline length. The deep longline has more hooks per basket and sinks deeper than the regular gear (Fig. 5). An increase of one hook per basket has been shown to increase the depth of the gear by about 10 m (Uozumi & Okamoto 1997). The longline fishery targeting swordfish is conducted at night when the fish migrate to the surface layer, and surface longline gear with three to four branch lines per basket is usually used. The depth of the hooks of surface, regular and deep longline gears range between 30-60 m, 50-120 m and 50-250 m, respectively. More important in regard to incidental catch of seabirds is the sinking speed of the hooks. However, the sinking speed through the surface layer (down to 50 m) does not seem to be affected by the number of hooks per basket (Uozumi & Okamoto 1997).

In the last few years new materials have been introduced into the Japanese tuna longline fishery of which braided nylon has become dominant. Although information on catching performance is scarce, the efficiency of these new gears seems to be better than that of the traditional ones. The type of material does not seem to affect the sinking speed of the hooks.

Management and assessment studies on tuna are conducted by several international fishery organizations including the International Commission for the Conservation of Atlantic Tunas (ICCAT), Inter-American Tropical Tuna Commission (IATTC), South Pacific Commission (SPC) and the Commission for the Conservation of Southern Bluefin Tuna (CCSBT). These bodies have recognized the necessity for observer programmes.

3.10 ATLANTIC OCEAN AND MEDITERRANEAN SEA PELAGIC LONGLINE FISHERIES

The fishery

Pelagic longlining in the Atlantic Ocean (including the Gulf of Mexico and the Caribbean Sea) and Mediterranean Sea is undertaken by a number of bordering countries, as well as by Japan, the Republic of Korea and Taiwan Province of China. Fishing for tuna and billfish including swordfish, (Brewster-Geisz *et al*. 1997, Folsom 1997a,b, Folsom et al. 1997, Weidner ms a,b) is regulated, including the setting of quotas, by the 23-member International Commission for the Conservation of Atlantic Tunas (ICCAT), which was established in 1966 (ICCAT 1985, see also Gaski 1993). Fishing for tuna takes place between 60°N and 50°S. It is to be noted that the most southerly fishing for southern bluefin tuna is considered in the Southern Ocean section below.

Pelagic longlining takes place on the high seas and also within EEZs: for example around Ascension Island in the South Atlantic where 50 Japanese vessels fished under license in 1989/90 (Ashmole *et al*. 1994). Tuna longlining under license commenced in Tristan da Cunha EEZ waters in 1995 with up to six vessels licensed a year (J. Glass *in litt*.).

In the past pelagic longlining took place for Atlantic salmon *Salmo salar* off the Norwegian coast by Norway and Denmark as well as around the Faeroes, but is now prohibited (Brun 1979, Follestad & Strann 1991, B. Olsen pers. comm. to E. Dunn).

Incidental catch of seabirds

Very little is known about incidental mortality of seabirds currently caused by pelagic longlining in the Atlantic Ocean and Mediterranean Sea. ICCAT has established a Sub-Committee on By-Catch and a Shark Working Group, but apparently does not collect data on mortality of seabirds (A. Penney pers. comm.). An observer programme commenced in 1996.

According to Dunn (1995), Cory's Shearwaters are taken by tuna fisheries in Macaronesian waters (off northwest Africa), but this may not be by longlining (L. Monteiro *in litt.*). Artisanal longlining for tuna out of Sao Tomé and Principé (Gulf of Guinea) has caught Brown Boobies *Sula leucogaster* (R. Corvas pers. comm. to R.M. Wanless).

In the North Atlantic limited information comes from the USA longline fishery (298 vessels setting *c.* 10 million hooks in 1995) for tuna, Swordfish and sharks in the western North Atlantic, Caribbean and Gulf of Mexico (National Marine Fisheries Service 1997d). In the six years 1992 to 1997 a total of 38 birds was reported killed with an observer coverage of *c.* 5%, suggesting on average that *c.* 130 birds were killed annually. Species recorded were Great Black-backed Gull (3), Herring Gull (7), unidentified gulls (8), Great Shearwater (10) unidentified shearwaters (3), Wilson's Storm Petrel *Oceanites oceanicus* (1) and unidentified seabirds (6) (calculated from National Marine Fisheries Service 1997d). In addition, a few Great Shearwaters, North Atlantic Gannets and gulls were caught alive. In apparent contradiction to the above information, Foster (1996) states that according to National Marine Fisheries Service observer data 150-3456 birds were killed in 1992 and 57-706 birds in 1993 by the US North Atlantic longline fishery for Swordfish. Further, D. Weidner (*in litt.*) cites data received from John Hoey, U.S. National Fisheries Institute, that 2900 observed sets in the U.S. Swordfish fishery in the Gulf of Mexico, Caribbean Sea and Atlantic seaboard yielded 40 seabird mortalities, mostly shearwaters along the mid-Atlantic coast of the U.S.A. These three data sets need to be reconciled.

The Venezuelan Swordfish fishery within the Caribbean Sea does not seem to catch birds, based on communications with observers, perhaps due to the fact that line-setting takes place at night (Weidner *et al*. in press).

In the South Atlantic information is available for pelagic longlining off South America. Vaske (1991) reported 58 White-chinned Petrels, six Spectacled Petrels, four Wandering Albatrosses *Diomedea exulans*, two Black-browed Albatrosses and one Antarctic Fulmar *Fulmarus glacialoides* (total 71 birds) taken during 52 fishing days off the coast of southern Brazil from 1987 to 1990. He estimated that *c.* 2650 birds may be killed annually by tuna longlining in the region. Daily catch rates were high, ranging from 0.8 to 15 birds/1000 hooks, with most mortality occurring during times of full moon. In a more recent study Neves & Olmos (1998) report 118 birds killed, nearly all in winter, by the swordfish longlining fishery in Brazilian waters in 1994/95. Birds identified were Wandering Albatross (1), Black-browed Albatross (33, 32 of which were juveniles), Yellow-nosed Albatross (17, 89% juveniles), White-chinned Petrel (6), Spectacled Petrel (6) and one Great Shearwater. Both Black-browed and Yellow-nosed Albatrosses showed a skewed sex ratio, with females predominating. The Spectacled Petrel is considered to be Endangered (Ryan 1998, see South American Demersal section above). The relatively low catch rates in this study were attributed to the fact that the swordfish-directed fishing vessels set their longlines at night (see Weidner *et al*. in press.

Stagi *et al.* (1998) made observations during nine fishing trips of the Uruguayan tuna and swordfish fishery in 1993-1994, showing that 277 albatrosses were killed at an overall catch rate of 10.5 birds/1000 hooks, or 4.7/1000 hooks, if the first trip when unweighted swivels were used is omitted. Black-browed Albatrosses (265) were the species most commonly caught. Utilizing what is apparently the same data set, Barea *et al.* (1994) reported in addition to the predominating Black-browed Albatrosses, six Wandering Albatrosses, one Yellow-nosed Albatross, one White-chinned/Spectacled Petrel and Great Shearwaters (no numbers given, reported as occasionally caught during line hauling). Of 37 Black-browed Albatrosses, 35 were females.

No quantitative information is available from elsewhere in the South Atlantic Ocean (not counting that for the Southern Ocean, see below). Ryan & Boix-Hinzen (1998) have highlighted the need for an observer programme and mitigatory measures for the licensed Japanese (30) and Taiwanese (90) tuna and swordfish longliners fishing within South Africa's Exclusive Economic Zone in both the Atlantic and Indian Oceans, because interviews with 25 Taiwanese fishing captains revealed that seabird mortalities occur, including of albatrosses, giant petrels, Pintado Petrels and White-chinned Petrels. This fishery will include 30 South African longliners from 1998 when some mitigation measures are expected to be enforced (Penney 1996, Anon. 1998, Ryan & Boix-Hinzen 1998, C.L. Moloney pers. comm.).

Bobbies *Sula* spp. and the threatened endemic Ascension Frigatebird *Fregata aquila* are considered to be at risk to longlining around Ascension Island, although direct observations of mortality are lacking (Ratcliffe in press). Information on seabird mortality around Tristan da Cunha is not yet available.

The Endangered Tristan Albatross *Diomedea dabbenena* and the Atlantic Yellow-nosed Albatross *Thalassarche chlororhynchos* of the Tristan da Cunha and Gough Islands in the central South Atlantic Ocean are caught by longliners, based on a few band recoveries (Cooper & Fraser 1986, Cooper 1988, 1994, Croxall & Gales 1998, unpublished records).

3.11 INDIAN OCEAN PELAGIC LONGLINE FISHERIES

The fishery

Information on pelagic longlining for tuna and related species in the Indian Ocean has been collated by the Indo-Pacific Development and Management Programme (IPTP) of the FAO since its inception in 1982. The IPTP is being replaced in 1998 by the 15-member Indian Ocean Tuna Commission (IOTC) which has managerial responsibilities and powers (Anon. 1997d). Commercial and artisanal longlining for tuna, tuna-like species, billfish, including swordfish, (Folsom 1997a,b, Folsom *et al.* 1997, Wildman 1997), and sharks takes place by countries bordering the Indian Ocean (importantly India, Indonesia, Pakistan, Sri Lanka and Thailand) and by Japan, the Republic of Korea and Taiwan Province of China. Fishing for Southern bluefin tuna in the Indian Ocean is considered in the Southern Ocean pelagic section below.

Incidental catch of seabirds

Practically no information has as yet been found on seabird incidental catch from pelagic longline fisheries in the Indian Ocean, other than by the southern bluefin tuna fishery (see Southern Ocean pelagic section below). Apparently, the IPTP has never collected information on seabird mortality. Pakistan reported to the FAO in 1998 that its tuna longliners occasionally caught seabirds (Pakistan 1998).

3.12 PACIFIC OCEAN PELAGIC LONGLINE FISHERIES

The fishery

Commercial and artisanal longlining in the tropical and temperate Pacific Ocean for tuna, tuna-like species, billfish and sharks is undertaken by Australia, Chile, China, Colombia, Ecuador, Japan, the Republic of Korea, Mexico, Peru, Taiwan Province of China and the USA (including Hawaii), as well as by a number of Pacific Ocean island states (Brewster-Geisz *et al*. 1997, Folsom *et al*. 1997, Nakano & Bayliff 1992, Bailey *et al*. 1996, Ito & Machado 1997, Weidner & Serrano 1997, WPRFMC 1997, C.F. Heberer *in litt*., J. Jahncke *in litt*., D. Weidner *in litt.*).

The Inter-American Tropical Tuna Commission (IATTC), established in 1950, studies and regulates tuna and billfish fishing in the eastern Pacific Ocean (east of 150°W) (Peterson & Bayliff 1985. The South Pacific Commission (SPC), which has no management responsibility, collates data on the tuna fisheries of the western and central Pacific Ocean (west of 120°W). It commenced an observer programme, which records bycatch, in 1995). The observer programme of SPC covered 38 trips in 1995 and 17 trips in 1996. Tuna fishing within the Federated States of Micronesia waters is managed by the Micronesian Maritime Authority which operates an observer scheme (Heberer 1994, C.F. Heberer *in litt.*). The Hawaiian domestic 120-vessel longline fishery for bigeye tuna, swordfish and sharks in the central North Pacific Ocean falls outside the geographical scope of both the IATTC and the SPC, and is managed by the U.S. Western Pacific Regional Fisheries Management Council (WPRFMC) (Ito & Machado 1997, Pacific Seabird Group 1997). An estimated seven million hooks were set in the first half of 1991, when the fleet was made up of 151 vessels (McDermond & Morgan 1993). An observer programe has operated since 1994.

Incidental catch of seabirds

In the central North Pacific Ocean, Laysan, Black-footed and Short-tailed Albatrosses have been at risk from longlining since at least the early 1960s, when hundreds of banded birds of both species were being caught on Japanese and Soviet Union tuna longlines and in nets (Fisher & Fisher 1972, Robbins & Rice 1974, King *et al.* 1979, see also the account above on demersal longline fisheries in the North Pacific). More recently, several publications have highlighted this continuing mortality (Nitta & Henderson 1993, Anon 1996b, Kalmer *et al.* 1996, Ito & Machado 1997, Pacific Seabird Group 1997, Paul 1997, Skillman & Flint 1997, WPRFMC 1997). Information from National Marine Fisheries Service observers on Hawaiian pelagic longliners (4% observer coverage) recorded catch rates of 0.113 Laysan Albatrosses/1000 hooks and 0.152 birds/1000 hooks for Black-footed Albatrosses, leading to estimates of total take of 1020±639 for 1994 and 1942±2435 in 1995 for the Laysan Albatross and 2135±970 and 1796±1498 for the Black-footed Albatross for the same years (Skillman & Flint 1997, WPRFMC 1997, NMFS 1998). Estimated total takes for 1996 for the same fishery are 625 Laysan Albatrosses (0.276 birds/1000 hooks) and 1189 Black-footed Albatrosses (0.083 birds/1000 hooks), based on an observer coverage of *c.* 5%. For the first nine months of 1997 estimated takes were 1628 and 2908 for the two species, respectively, showing an increase over the previous year (E.N. Flint *in litt.*). The Western Pacific Regional Fisheries Management Council held a workshop in October 1998 to evaluate the effects of the Hawaiian pelagic longline fishery on the population status of the Black-footed Albatross, the rarer of the two species affected (Cooper & Cousins in press.). This species has been accorded the IUCN conservation status of Vulnerable, based on observed rates of decline (Croxall & Gales 1998). Importantly, the workshop estimated that the incidental catch of Black-footed Albatrosses by all longline fisheries within its range may be as high as 7300 a year (Cooper & Cousins in press).

Little information has been obtained on the incidental mortality of seabird species other than albatrosses in the domestic Hawaiian longline fishery. In four years of the mandatory observation programme only two unidentified shearwaters were reported, both from south of Hawaii (E.N. Flint *in litt.*).

Studies of bycatch by the IATTC in the eastern Pacific Ocean have been restricted to the problem of cetaceans trapped by purse-seine nets (Peterson & Bayliff 1985) and bycatch of birds has not been studied by the Commission (M.A. Hall *in litt.*). However, some species of albatrosses and petrels may be at risk from pelagic longlining off the Pacific coasts of South America and around the Galapagos (Spear *et al.* 1995, see also South American demersal section above). A banded juvenile Chatham Albatross was taken by a swordfish longliner off the coast of Chile in 1995 (Gales 1998) and Warham (1982) reported a Southern Buller's Albatross taken by a longliner in the Pacific Ocean 2000 km southwest of the Galapagos Islands in October 1979. A banded Black Petrel has been caught by a fishing vessel (type unknown) off Peru (J. Molloy *in litt.*) so this rare species may be at risk to longliners off the Pacific coast of South America.. A newly commenced artisanal fishery for dorado or dolphin *Coryphaena hippurus* in Peruvian waters has reportedly taken Waved Albatross and Blue-footed Booby *Sula nebouxii* (J. Jahncke *in litt).*

Based on observer data, Bailey *et al.* (1996) reports no seabird mortality from the longline fishery for tuna in the tropical western Pacific Ocean. Garnett (1984) found no records of incidental mortality from commercial tuna longlining in the South Pacific, defined as between 160°E and 125°W. Heberer (1994) reports only one bird (species not recorded) caught out of 700 000 observed hooks on 51 fishing trips in the Federated States of Micronesia tuna fishery in the tropical Pacific Ocean during the period 1993-1994. Information from the temperate western Pacific Ocean off Australia and New Zealand is discussed below in the Southern Ocean region.

3.13 SOUTHERN OCEAN PELAGIC LONGLINE FISHERIES

The fishery

Pelagic longline fishing in the southern Atlantic, Indian and Pacific Oceans (here defined as the Southern Ocean) has been undertaken primarily for southern bluefin tuna since 1955 with subsequent large fluctuations in the size of the fishery and its geographical scope (Polachek & Tuck 1995, Tuck & Polacheck 1997). Other species of tuna and swordfish may also be caught. Fishing takes place in international waters and in the EEZs of South Africa, Australia and New Zealand. Within EEZs fisheries may be domestic, joint-venture or foreign, with a trend towards a reduction of licensed foreign vessels and an increase in domestic fishing. Major countries involved are Australia, Indonesia, Japan, the Republic of Korea, New Zealand and Taiwan (Bergin & Haward 1994).

The Commission for the Conservation of Southern Bluefin Tuna (CCSBT), established in 1994, sets quotas and collects information through an observer programme, both on the high seas and within national EEZs (Bergin & Haward 1994, CCSBT 1996). Members of the CCSBT are Australia, New Zealand and Japan, so the fishing efforts of the

Republic of Korea and Taiwan in the Southern Ocean are not regulated by this commission (Hayes 1997). Prior to 1994 the three member countries acted cooperatively in the management of southern bluefin tuna under trilateral agreements. The CCSBT has established an Ecologically Related Species Working Group (CCSBT-ERS) which considers seabird mortality. It first met in late 1995.

A Real Time Monitoring Programme (RTMP) for the southern bluefin tuna fishery was established in 1991, which includes observations of incidental catch of birds by both Australia and Japan (Tuck *et al.* 1997, Uozumi *et al.* 1997). The observers record detailed information such as description of mitigation devices, weather condition and number of birds around the vessel during line setting, and seabirds caught are sampled for identification of species.

Because most seabirds killed by the southern bluefin tuna fishery breed with the area covered by CCAMLR (although they are caught north of it) , close links between the two Commissions are being fostered, including at the level of the CCAMLR-IMALF and the CCSBT-ERS. The recent development of the longline fishery for Patagonian Toothfish within CCAMLR (see relevant section above) has increased the need for such collaboration, because there is a large overlap in the seabird species killed by the two fisheries.

Incidental catch of seabirds

Information on seabird mortality caused by the southern bluefin tuna fishery currently comes from three main sources: domestic observer programmes of Australia and New Zealand and from that on the high seas administered by the CCSBT. There is currently no observer programme for the fishery within the South African EEZ (Anon. 1998b, Ryan & Boix-Hinzen 1998, J. Augustyn pers. comm.). Information is also available from band recoveries, including from prior to observer programmes (e.g. Robertson & Kinsky 1972, Croxall & Prince 1990, Battam & Smith 1993, Gales & Brothers 1995).

The first quantitative information on seabird mortality (which was seminal in raising concern generally) is that of Brothers (1991) who estimated that Japanese longlining activities in the Southern Ocean south of 30°S (107.9 million hooks a year) caused the death annually of up to 44 000 albatrosses in the 1980s, calculated from an observed average catch rate of 0.41 birds/1000 hooks within the 200-nautical mile Australian Fishing Zone (AFZ) off Tasmania in 1988. The Blackbrowed Albatross was the species most abundantly taken. Other species observed caught on longlines were Wandering Albatross (*sensu lato*), Grey-headed Albatross, Shy Albatross *Thalassarche cauta* (*sensu lato*) Light-mantled Albatross *Phoebetria palpebrata* and Southern Giant Petrel. Juvenile albatrosses predominated.

Brothers & Foster (1997) give limited data for the Australian domestic tuna fishery within the AFZ for 1994/95. Mean catch rate was 0.92 birds/1000 hooks. The Shy Albatross (n = 7) was the species most commonly taken of 11 birds identified. Other species were Great-winged Petrel and the Short-tailed Shearwater *Puffinus tenuirostris*. Only three petrels were killed in 1994-1996 out of 74 753 hooks observed (Whitelaw 1995, 1997). In 1996 one Campbell Island Albatross *T. impavida* was caught alive from 2100 hooks (Brothers *et al.* 1998b). In 1997 25 020 observed hooks caught four birds: a Shy Albatross, a Great-winged Petrel, a Wedge-tailed Shearwater *Puffinus pacificus* and an (alive) Australasian Gannet *Morus serrator* (Brothers *et al.* 1998c). Reid & James (in press) record Chatham Albatrosses interacting with longliners off Tasmania.

Information from Japanese vessels fishing within the AFZ is given by Klaer & Polacheck (1995, 1997a,b). The total estimated catch of seabirds was 1217 for 1991, 2981 for 1992, 3590 for 1993 and 2817 for 1994. Estimates for 1995 are 1085 birds and for 1996, 1503. For these three years 1992-1994, 78% (n=513) were albatrosses, primarily Black-browed and Shy, but also Wandering, Royal, Grey-headed, Yellow-nosed, Light-mantled Sooty and Sooty *Phoebetria fusca* Albatrosses. Other species identified were Southern and Northern Giant Petrels, White-chinned Petrel, Grey Petrel *Procellaria cinerea,* Fleshfooted and Sooty Shearwaters *Puffinus griseus* and Subantarctic Skua. Species identification was not available for 1995 and 1996. Catch rates varied from 0.10 birds to 0.24 birds/1000 hooks. Summer catch rates were generally higher than in winter. The above totals and catch rates do not include hooked birds lost during hauling, thought to be as much as 27% (Brothers 1991). Information for this fishery based on recovered corpses, including of banded birds, is also given by Gales & Brothers (1995) and Gales *et al.* (1998). Black-browed Albatrosses formed a quarter of the 571 corpses identified in 1995. In 1996 and 1997 an estimated 854 birds (0.14 birds/1000 hooks) and 160 birds ().02/1000 hooks), respectively (12 species in both years, mainly albatrosses) were killed by Japanese tuna vessels within the Australian AFZ (Brothers *et al*. (1998b,c). The reduction in numbers of birds killed from 1988 to 1997 by the Japanese fishery in the AFZ is mainly thought due to decreasing fishing effort, as well as changes in fishing practices (Brothers *et al*. 1998c).

Early information for New Zealand waters is given by Bartle (1990) who reported Grey Petrels (16; of which 15 were females), Campbell Albatrosses *Thalassarche impavida* (8) and one Antipodean Albatross *Diomedea antipodensis* taken by tuna longliners in June 1989. Parrish (1991) reports a tuna-hooked Buller's Albatross *T. bulleri* (*sensu lato*) found on a New Zealand beach in July 1991. Quantitative information from New Zealand waters is given by Murray *et al.* (1993) for the period 1988-1992 and by Imber (1994a,b) from two separate cruises. Estimated mortality decreased from 3652 birds in 1988 to 360 in 1992 (Murray *et al*. 1993). Fourteen species of albatrosses and petrels were identified from 135 birds collected, of which 50 were petrels, nearly all Grey Petrels, and 85 albatrosses (including endemic species). Capture rates varied from 0.04 to 1.90 birds/1000 hooks geographically and decreased over the time period. More recent data for New Zealand waters are given by Anon. (1997b), covering the period 1987 to 1995 for 24 species. A total of 783 birds was observed caught by licensed foreign, chartered (both categories Japanese) and domestic vessels. The most commonly caught of 18 species identified (n = 413) were White-capped *Thalassarche steadi* (22%) and Buller's (11%) Albatrosses, both New Zealand endemics, and Grey Petrels (31%) (Table 7). In the 1996/97 year, 280 birds were observed captured, including for the first time one individual of the rare Chatham Albatross, whose IUCN conservation status is Critically Endangered (Croxall & Gales 1998). This species was also taken by demersal longliners in the same year (see Australasian Demersal section above). The rare endemic and Vulnerable Westland and Black Petrels *Procellaria westlandica* and *P. parkinsoni* were also reported caught, although in small numbers (Table 8).

Catch rates over the period 1987 to 1995 varied from 0.02 to 1.37 birds/1000 hooks (Anon 1997b), and also varied geographically and with phase of the moon for night sets (see also Duckworth 1995). Bartle (1995), utilizing observer data from the New Zealand tuna fishery from 1987 to 1994, estimated that the licensed Japanese fleet killed 11 700 birds, of which 7500 were albatrosses. He also estimated that 20 000 Grey Petrels had been killed by this fishery since 1973, mainly (89%) breeding females. However, Baird (1996) using the observer data from 1987 to 1995 estimated that only 9036 seabirds had been caught by

Japanese tuna longliners in New Zealand waters, with a decrease from 3979 in 1989 to 167 in 1995, due both to a decrease in effort and in catch rate.

No quantitative information is available for fishing for southern bluefin tuna in the South African EEZ although bird mortality does occur (Ryan & Boix-Hinzen 1998, see Atlantic Ocean Pelagic section above).

RTMP data collected by Australian observers on the high seas for 1995 recorded 208 albatrosses and 37 petrels by eight vessels, with catch rates of 0.01 to 1.52 birds/1000 hooks (Tuck *et al.* 1997). No species identifications were made. Equivalent Japanese data for two of the main fishing regions west of Australia and south of Africa are of 1568 birds of 17 species (nine albatross species) caught from 1992 to 1996 (Uozumi *et al.* 1997, see also Takeuchi *et al.* 1997). Together, Black-browed, Grey-headed and Shy Albatrosses (*sensu lato*) and White-chinned Petrels formed 77%. Catch rates were in the range <0.1 to 0.4 birds/1000 hooks. Ryan & Boix-Hinzen (1998), utilizing Japanese RTMP data, have roughly calculated that 20 000 birds may be killed annually off Africa on the high seas.

For the southern bluefin tuna longline fishery as a whole, it is thought (e.g. Murray *et al.* 1993, Polacheck & Tuck 1995) that the introduction of various mitigation measures such as night setting and the use of streamer lines (not here discussed in detail, but see Klaer & Polacheck 1997c) has led to a reduction in catch rate from that first reported by Brothers (1991). However, in order to make an estimate of the annual bycatch for the fishery as a whole more information is needed from observer programmes, including for the currently large Taiwanese fishing fleet (Tuck & Polacheck 1997, Ryan & Boix-Hinzen 1998).

Observer programmes do not record all birds killed, so species rarely caught may be overlooked. This is of significance when the species itself is very rare. For example, the Amsterdam Albatross *D. amsterdamensis*, with an estimated population of less than 100 birds, has been taken by a longliner at least once, in 1992 (Gales 1993, Weimerskirch *et al.* 1997, Gales 1998). This single-island endemic species has been accorded the IUCN conservation status of Critically Endangered (Croxall & Gales 1998).

3.14 SEABIRDS AT RISK FROM LONGLINING

Based on the current review a total of 61 species of seabirds has been recorded as killed by longline operations on at least one occasion (Table 9). For some species the level of incidental mortality so caused is considered not to be sustainable, and their populations are in decline. Partially as a consequence, 25 (39%) of the 62 affected seabird species have been accorded a threatened status by the World Conservation Union as either Critically Endangered, Endangered or Vulnerable, most importantly the albatrosses (Table 7).

Table 7. Numbers of seabirds landed dead and returned for identification by the combined tuna fleet in New Zealand waters, 1988-1996

Species	No seabirds returned for identification						
	Japanese vessels		Chartered Japanese		NZ vessels		% Total
	N	S	N	S	N	S	
New Zealand White-capped albatross (*Thalassarche Steadi*)	1	5		83			22
Southern Buller's albatross (*Thalassarche bulleri*)		17		25		3	11
Campbell albatross (*Thalassarche impavida*)	16	6	7	6			8
Auckland Island wandering albatross (*Diamedea gibsoni*)	10		8	4			5
Southern black-browed albatross (*Thalassarche melanophrys*)	11				2		4
Wandering albatross (*Diomedea exulans* ssp)	3	2		7			3
Antipodes Islands wandering albatross (*Diomedea antipodensis*)	7			1			2
Southern royal albatross (*Diomedea epomophora*)		3		5			2
Grey-headed albatross (*Thalassarche chrysostoma*)	1	5					2
Salvin's albatross (*Thalassarche salvini*)	3						1
Light-mantled sooty albatross (*Phoebetria palpebrata*)				3			1
Grey petrel (*Procellaria cinerea*)	118	1	3	1	4		31
White-chinned petrel (*Procellaria aequinoctialis*)		2		31			8
Sooty Shearwater (*Puffinus griseus*)				3			1
Southern giant petrel (*Macronectes giganteus*)	2						<1
Black petrel (*Procellaria parkinsoni*)					2		<1
Northern giant petrel (*Macronectes halli*)				1			<1
Westland petrel *Procellaria westlandica*)		1					<1
Total of all species	172	42	18	170	8	3	100

N = North S = South

Regionally, incidental mortality of seabirds is most severe, with catch rates exceptionally approaching or even exceeding 10 birds/1000 hooks set, at high latitudes in the cold fish- and bird-rich waters off the North and South Atlantic, North Pacific and Southern Oceans. Very little mortality seems to occur in the tropical Atlantic, Indian and Pacific Oceans but data are mostly lacking. An exception is the mortality of Laysan and Blackfooted Albatrosses in the Pacific Ocean in the vicinity of Hawaii from longline fishing for tuna and broadbill swordfish.

Species of special concern include the Endangered (World Conservation Union criteria) Spectacled Petrel, which is taken in numbers off the Atlantic coast of South America and is a single-island endemic with a small population. Other rare and threatened species known to be taken by longliners are the Vulnerable Short-tailed Albatross of the North Pacific and the Critically Endangered Amsterdam, Endangered Tristan and Northern Royal and Critically Endangered Chatham Albatrosses of the Southern Ocean. The situation with the Vulnerable Waved Albatross of the Pacific Ocean requires investigation.

Other species of serious concern are the remaining albatrosses Diomedeidae, the Southern and Northern Giant Petrels. and the Whitechinned and Grey Petrels of the Southern Ocean, which are taken in their hundreds or thousands by the large longline fisheries for Southern bluefin tuna and Patagonian toothfish.

Although the Northern Fulmar may be taken in large numbers its very large population which numbers in the millions suggests it is not a conservation risk, although more information is required.

Table 8. Conservation status of seabirds caught on longlines (CE=Critically Endangered, E=Endangered, V=Vulnerable, NT=Near Threatened, LR=Low Risk and DD=Data Deficient)

Species	IUCN status
Macaroni Penguin *Eudyptes chrysolophus*	V
Gentoo Penguin *Pygoscelis papua*	
Divers *Gavia* sp.	
Wandering Albatross *Diomedea exulans*	V
Tristan Albatross D. dabbenena	E
Antipodean Albatross *D. antipodensis*	V
Gibson's Albatross *D. gibsoni*	V
Southern Royal Albatross *D. epomophora*	V
Northern Royal Albatross *D. sanfordi*	E
Amsterdam Albatross *D. amsterdamensis*	CE
Short-tailed Albatross *Phoebastria albatrus*	V
Waved Albatross *P. irrorata*	V
Laysan Albatross *P. immutabilis*	LR
Black-footed Albatross *P. nigripes*	V
Black-browed Albatross *Thalassarche melanophrys*	LR
Campbell Albatross *T. impavida*	V
Buller's Albatross *T. bulleri*	V
Pacific Albatross *T.* nov. sp.	V
Shy Albatross *T. cauta*	V
Chatham Albatross *T. eremita*	CE
Atlantic Yellow-nosed Albatross *T. chlororhynchos*	DD
Indian Yellow-nosed Albatross *T. carteri*	V
Grey-headed Albatross *T. chrysostoma*	V
Sooty Albatross *Phoebetria fusca*	V
Light-mantled Sooty Albatross *P. palpebrata*	DD
Southern Giant Petrel *Macronectes giganteus*	
Northern Giant Petrel *M. halli*	NT
Northern Fulmar *Fulmarus glacialis*	
Antarctic Fulmar *F. glacialoides*	
Cape/Pintado Petrel *Daption capense*	
Great-winged Petrel *Pterodroma macroptera*	
Grey Petrel *P. cinerea*	
White-chinned Petrel *P. aequinoctialis*	
Spectacled Petrel *P. conspicillata*	E
Black Petrel *P. parkinsoni*	V
Westland Petrel *P. westlandica*	V
Cory's Shearwater *Calonectris diomedea*	
Flesh-footed Shearwater *Puffinus carneipes*	
Great Shearwater *P. gravis*	
Sooty Shearwater *P. griseus*	
Short-tailed Shearwater *P. tenuirostris*	
Manx Shearwater *P. puffinus*	
Wilson's Storm Petrel *Oceanites oceanicus*	
Cormorants *Phalacrocorax* sp.	
North Atlantic Gannet *Morus capensis*	
Cape Gannet *M. capensis*	NT
Blue-footed Booby *Sula nebouxii*	
Brown Booby *S. leucogaster*	
Great Skua *Catharacta skua*	
Subantarctic Skua *C. antarctica*	
Herring Gull *Larus argentatus*	
Lesser Black-backed Gull *L. fuscus*	
Great Black-backed Gull *L. marinus*	
Glaucous-winged Gull *L. glaucescens*	
Glaucous Gull *L. hyperboreus*	
Black-legged Kittiwake *Rissa tridactyla*	
Common Guillemot/Murre *Uria aalge*	
Brunnich's Guillemot/Thick-billed Murre *U. lomvia*	
Atlantic Puffin *Fratercula arctica*	

It is clear that very little is known about the incidental mortality of seabirds in most of the world's longline fisheries. Quantitative data amenable to statistical analysis are available from only a handful of fisheries, and for many if not most longline fisheries even anecdotal information appears lacking.

4. TECHNICAL GUIDELINES TO REDUCE SEABIRD INCIDENTAL CATCH BY LONGLINE FISHERIES

4.1 INTRODUCTION

This section is a comprehensive review of seabird mitigation measures in place, being tested or recommended for reducing the incidental catch of seabirds by longline fisheries. Previous reviews have been undertaken by Alexander *et al*. (1997) who summarized the contribution of participants at a workshop on the subject and by Bergin (1997). Published and unpublished information, and contributions solicited from various experts have been taken into account.

Why seabirds are killed and what measures can be used to prevent this in longline fisheries has been under investigation for the past 10 years. A variety of mitigation measure options was identified at the outset of these investigations (e.g. Brothers 1991). Development of appropriate mitigation measures, effective because fishers do not need to be forced to adopt them are essential. It is also necessary to examine the potential mitigation measures which benefit birds only and which as a consequence may be less readily adopted by fishers. Such measures may have a short-term role of mitigation while other options more favourable to industry are pursued.

Regardless of the measure, the necessity for bird catch reduction is essential. Killing seabirds whatever the consequences to particular species, is undesirable and fortunately this view is shared by some fishers. However, in reality the only serious effort by fishers so far to address the problem has been precipitated by actions external to their industry. But ignorance of the extent of the problem, and not knowing what to do about it is arguably justification for past inactions and recent slow progress. The role of education in relation to mitigation measures and an understanding of seabird bycatch can therefore be an important component of solving the problem.

Development of mitigation measures and their use by fishers has been constantly changing. Highly effective measures already exist but fishers either do not know about them, find them unsuitable for a variety of reasons, or simply cannot be bothered with them. Concepts of methods more convenient for fishers do exist but these seem to be more complex, expensive and slow to develop. Even more effective methods may be discovered in the future. Therefore, the current confusion about what measure, or suite of measures to use, how to apply them, and when to apply them may be ongoing until more satisfactory methods have taken their place. Understanding this dilemma necessitates flexibility, particularly in relation to regulations about mitigation measures.

A mutually beneficial solution to the seabird problem is clearly achievable but will require an ongoing co-operative commitment to mitigation measure development and the widespread use of these measures. There are however, divided opinions on the most effective course to overcome incidental mortality of seabirds during longline fishing operations. The

options are to work with fishing industries to develop solutions or to use political pressure and legislation with or without these solutions. To be realistic, whatever the process it will most
likely necessitate development of measures that are economically or operationally advantageous to fishers.

Perhaps there are simply too many unforeseen circumstances in longline fishing that will always compromise the effectiveness of mitigation measures, such as line tangles, main line jams during setting, not enough bait thawed for a set so frozen bait is used, setting lines during daylight to avoid losing a fishing opportunity to approaching bad weather, or a whole hook box lost overboard leaving up to 100 baited hooks exposed on the sea surface. To take account of the unexpected does narrow down options that will be effective. The time is fast approaching when all currently feasible options of mitigation measure development will have been exhausted. If in the end these are unsuccessful because fishers have failed to use them, will the next option in mitigation development be a consideration of fishing practices other than longlining to catch fish such as tuna?

Lastly, not every longline fishery requires the adoption of mitigation measures because incidental catch of seabirds does not universally occur (see section 3 above).

4.2 WHAT IS A MITIGATION MEASURE?

A mitigation measure, in this instance can best be described as a modification to fishing practices and/or equipment that reduces the likelihood of seabird incidental catch. This description includes all the strategies that can be employed for the purpose of reducing seabird mortality, ranging from fishing area or season closures to subtle adjustments in fishing equipment. Modifications, new fishing practices and equipment are more acceptable to fishers than are fishing area or season closures and therefore here lies the greatest potential for solution. Such measures are the focus here. Education focused on describing the issue of seabird incidental catch to fishers, including economic as well as biological and social impacts and suggested mitigation measures, can also be a powerful tool for institutionalizing mitigation measures in longline fisheries.

Measures of this type fall into two categories, those that exist and are currently in use and those that are only concepts requiring investigation and development. The aim of both is to alter the circumstances that lead to birds being killed. This is achieved by the following processes: preventing baited hooks being visible to birds; preventing access to baited hooks; reducing the potential of hooks to kill birds that take them; and decreasing the incentive for birds to follow longline vessels. How the measures or combinations of these measures function are described separately for each.

4.3 HOW BIRDS GET CAUGHT ON LONGLINES

Understanding the circumstances that lead to the death of birds in longline fisheries is essential in the process of determining how mortality can be prevented. Describing these circumstances will provide a clearer understanding of how and when a mitigation measure can reduce mortality. Summarized here, these circumstances are also noted in each mitigation measure description.

Perhaps the biggest influence on this aspect of the problem and therefore on solution options is the actual type of longline fishing concerned. Of most relevance is the variation in equipment type and usage between longlines that are designed to set and catch fish in the mid-water (pelagic longlining), and those set for catching fish on the ocean floor (demersal longlining). It is essential to maintain the distinction between demersal and pelagic longlining in terms of mitigation measures. This is because measures appropriate for one are sometimes inappropriate or less effective for the other. But because the basic reasons for bird problems are the same in all longline fisheries, many preventative measures will be universally appropriate. It is important to remember this so as to avoid time wasted re-inventing methods or re-assessing catch rate response. In general the most effective of the measures do universally apply (Table 9).

Longline methods other than those with the general titles of pelagic or demersal, such as droplines, have different bird problems unrelated to the issues discussed in this report, and they have therefore not been dealt with here.

The most common cause of incidental mortality is that birds take baited hooks during the process of putting hooks in the water (line setting) and drown. Birds have access to baited hooks because of how hooks are set or their descent rate in the water. In a similar way birds are also caught during the process of getting the hooks out of the water (line hauling) but are less often killed. Despite the fact that many seabirds caught during the line hauling stage may be released alive, the goal is still to prevent their capture.

Further bird mortalities occur from hooks remaining in released birds or hooks being ingested in discarded offal and fish bycatch. Also, in certain circumstances birds become entangled in line sections or are impaled on hooks incidentally. Apart from these accidental deaths, deliberate killing to stop birds taking bait or to use them for food also occurs. Shooting is a method commonly employed in these instances.

4.4 THE EFFECTIVENESS OF MITIGATION MEASURES

Although this subject is dealt with in more detail for each mitigation measure separately below it is both a complicated and vital aspect for consideration. Firstly, there are the ways in which each separate measure could be effective singly and in combination. Unravelling the complexities can only be achieved by having a clear definition of the goal. Is it simply to reduce the numbers of birds that are killed irrespective of other consequences? Is it to do this but at no expense to the fishers? Or is there some room for compromise? Perhaps there is even a way that is in all respects effective - financially, environmentally and operationally.

The next complication is to demonstrate or quantify the degree of effectiveness and this depends on what the goal really is. The goal may be set to an appropriately quantified bird catch rate against which to measure performance. Alternatively, having an objective of zero birds caught, provided this is actually achievable, can simplify the whole process considerably. Quantifying effectiveness is impossible if there is any uncertainty about measures being used consistently or correctly. One way of defining an effective measure may be to describe it as one that will be used regardless of compliance considerations.

In addition to the above difficulties it is also necessary to consider the results of work that have attempted to define the effectiveness of mitigation measures. Any such study must be used with the utmost caution because results can be misleading and precipitate highly inaccurate interpretation. Despite having perhaps the most comprehensive data set available anywhere from which to attempt measurement of mitigation effectiveness and the potential influence of other variables on seabird mortality, Brothers *et al.* (submitted ms) had limited success. The limitations of using such techniques for reducing bird incidental catch must be recognised. If not, the danger of being obsessed with the requirement for small coefficients of variation in the measurement of mitigation performance will undoubtedly subject fishers to many years of confusion, governments to many years of expensive monitoring and seabird populations to further unnecessary declines. There is a need to verify or quantify the effectiveness of mitigation measures and whereas statistical verification seems unavoidable there is clearly a strong need for pragmatism.

In all probability those measures requiring extensive evaluation to determine their effectiveness will be the ones to require enforced compliance. And, whereas this is undesirable or perhaps impossible in the long-term, measures of this nature may have a role in the short-term. It is here that accelerating progress of evaluation and adoption can be important. For this, controlling or manipulating the normal routine of fishing may prove highly effective. "Experimental fishing" is perhaps the only means of rapidly and precisely evaluating the contribution of alternatives to fishing equipment or techniques for bird incidental catch reduction, among all other variables.

able to manipulate variables more strictly, a large amount of data may still be required to provide meaningful results. And ultimately, even the most favourable results from such processes may do nothing to persuade fishers to adopt the measure. Also, in a process of this sort it is essential to remember the earlier warning about misguiding results. Here the development of bird-scaring lines serves as a good example (see below).

Table 9. Summary table of mitigation measures

	Type of Measure	Fishery suitability		Stage of development	Compliance monitoring needs	Relative cost initital or ongoing	Safety factor for crew	Negative impact on		Seabird catch reduction efficiency
		Demersal	Pelagic					Target catch	Non-bird by catch	
A1a	Weighting the longline gear	good	moderate	partly developed	Low	high initial, low ongoing	caution needed	reduction concerns	specific problem potential	very high
A1b	Thawing bait and/or puncturing swim bladder	poor	good	part development and tested	High at present	low ongoing	safe	no	no	moderate potential
A1c	Line-setting machine	moderate	moderate	developed, partly tested	None	moderate initial, low on-going	safe	no	no	moderate potential
A2	Below-the-water setting	moderate	moderate	under development,	None	high initial	safe	no	no	total
A3	Bird scaring line (Streamers lines, buoy lines)	good	moderate	developed, tested, refinement needed	Variable, by observation	low ongoing	safe	no	no	high but variable
A4	Bait Casting Machine	none	poor	developed, partly tested	None	high initial	to consider	no	no	moderate potential
A5	Brickle curtain	good	good	developed	Variable, by observation	low	safe	no	no	very high
A6	Artificial baits or lures	poor	poor	concept only	None	high initial low ongoing	safe	unknown	unknown	high potential

	Type of Measure	Fishery suitability		Stage of development	Compliance monitoring needs	Relative cost initital or ongoing	Safety factor for crew	Negative impact on		Seabird catch reduction efficiency
		Demersal	Pelagic					Target catch	Non-bird by catch	
A7	Hook modi-fications	poor	good	at concept stage	None	moderate initial	safe	unknown	unknown	moderate potential
A8	Acoustic deterrent	moderate	poor	limited testing	High	low initial	to consider	no	no	unknown, but very low likelihood
A9	Water cannon	moderate	poor	limited testing	High	moderate initial	safe	no	no	unknown but low likelihood
A10	Magnetic deterrent	moderate	poor	limited testing	Low	moderate initial	to consider	no	no	very low likelihood
B1	Reduce visibility of bait (e.g. night setting)	good	good	currently in use in some fisheries	Moderate by observation	widely none, locally high initial	safe	reduction concerns	increase potential	very high
B2	Reduce the attractiveness of the vessel (e.g. reduce offal discharge)	good	moderate	developed	None	moderate initial	safe	no	no	very high (line hauling)
B3	Area and seasonal closures	poor	poor	not used	High	unknown	safe	reduction concerns	no	high potential
B4	Preferential licensing for vessels	good	good	concept	Variable	unknown	safe	no	no	high
B5	Release live birds	moderate	moderate	developed	None	no	safe	no	no	moderate potential

4.5 A BRIEF HISTORY OF MITIGATION MEASURES

Longline fishing has reached a peak in the level of technological sophistication to catch fish and only recently have fishers realized they can no longer afford to disregard the destructive capacity for target fish, let alone bycatch. In the past fishers have been unaware of their effect on seabird populations; nearly 30 years of catching albatrosses and other seabirds elapsed before anyone became aware that this was a potentially serious matter. Fishing technology has continually changed, in pursuit of higher profits, irrespective of bird catch rates and only recently has there been any need or incentive for fishers to consider how to avoid catching birds. There is no doubt that fishers need to understand the importance of not catching birds because if they had enough incentive to prevent bird deaths they would be quite capable of developing fishing practices that did this.

However, fishers were not totally unaware of a bird problem. Prior to 1988 when the problem first became widely known, losing bait to birds and having less bait for fish was something to avoid in order to maximise profits from fishing effort. Fishers had no concept (and many still do not) of bird populations and the consequences of catching a few individuals. After all, each fishing vessel may catch only one or two birds a day, sometimes none for many days and each day the impression is of just as many birds flying around the ship. It is understandable that fishers had no perception of a problem. Further, they have little understanding of the population biology of seabirds and why their practice threatens the survival of albatrosses. Concepts such as delayed maturity, year-long breeding cycles, biennial breeding and long life spans were not known.

The financial incentive of preventing birds taking bait has not always been sufficient for fishers to take action. There have been changes in the past to fishing equipment and its use that have coincidentally reduced bird catch rates. At the same time some changes to fishing equipment have increased bird catch rates. These changes occurred for economic reasons and. bird catch rates were not usually a consideration. It is unclear whether the changes in equipment and techniques have resulted in an overall increase or decrease in seabird mortality. However, anecdotal information from fishers suggests that bird catch rates are lower now than a decade or two ago.

In the past, the less-mechanised operations meant fishers caught fewer fish. With gear and vessel refinement fishing effort capacity increased, distribution and persistence of the fishing effort expanded, particularly into higher latitudes with their relatively high bird populations. Mechanization enabled fishing effort to increase (more effort, more birds) but apart from this impact on seabird catch rates mechanization in other ways reduced bird catch rates. Branch line coiling machines for example brought about a dramatic reduction in the catch rate of birds. But, lighter, more buoyant lines were introduced and these have the capacity to kill more birds.

Most mitigation measures and regulations that have been adopted by various fisheries or nations originated from work undertaken in the Japanese tuna longlining fishery in the Australian sector of the Southern Ocean. From the start, in 1988 this work (Brothers 1988, 1991) prescribed the following to reduce bird mortality and improve fishing efficiency: use of bird-scaring lines, mechanizing bait throwing, sinking hooks faster by adding weight and confining line setting to night. The Japanese tuna longline industry has been very much involved in this work and deserve credit for the progress of mitigation measure developments that are progressively being adopted world-wide. These same measures are still prescribed today and have been further developed or refined to offer greater options and or combinations of options for various fisheries. These are described below.

4.6 LINE SETTING AT NIGHT

Description

Night setting alone as a mitigation measure can virtually eliminate seabird mortality in some fishing grounds and in others will assist greatly in minimising mortalities because most of the seabirds that are caught mainly forage during the day. Darkness also affords baited hooks additional protection by concealing them from birds which is particularly beneficial if slow sinking baits are being set and if bird scaring lines are not in use.

History

Confining line setting to night time was first proposed in 1988 as the simplest solution to overcome seabird mortalities (Brothers 1991). Since then, this strategy has been widely promoted and also prescribed in regulations (see section on process of adoption) for several demersal as well as pelagic longline fisheries. However, night setting remains unpopular among fishers (see section on effectiveness).

As early as 1990 Japanese tuna vessels fishing in the New Zealand and Australian regions responded to concerns over high bird catches with a trend toward setting more hooks at night but it was not until the measure was regulated in New Zealand that night-setting operations prevailed there. However the proportion of hooks that are set at night time in the Australian Fishing Zone has remained at less than 20% (Gales *et al.* 1998). Domestic fishery vessels in Australian waters and no doubt elsewhere have of their own volition in recent times tended toward a predominance of night setting in bird-problem waters.

Effectiveness

Bird catch rate reductions due to night setting reach 60-96% (Murray *et al.* 1993, Klaer & Polacheck 1995, Cherel *et al.* 1996, Brothers *et al.* submitted ms). Effectiveness varies between fisheries and seasonally within a fishing region due to some birds (e.g. White-chinned Petrels) being more active than others during the night. Ashford *et al.* (1995) and Barnes *et al.* (1997) reported only White-chinned Petrels caught on hooks set during the night and Brothers (1995a), when few White-chinned Petrels were present observed no birds at all killed on night-set lines. Even when this species is common less will be killed by night-set hooks compared to day-set hooks (Gales *et al.* in press).

Night setting is less effective during bright moonlight and in high latitudes during summer, when hours of darkness are few or even absent. Birds are three to six times more likely to be caught in bright moonlight than when there is no moon and hooks set during a full moon resulted in 2.1 times more bird mortalities than during a new moon (Duckworth 1995, Moreno *et al.* 1996, Barnes *et al.* 1997, Brothers *et al.* submitted ms).

Further improvement to the night-setting catch rate reduction may also be possible if the findings of Barnes *et al.* (1997) are widely applicable, indicating birds are more susceptible to being caught in the period two to five hours before sunrise.

Despite such occasions of higher catch rate potential during night setting, it is essential to remember that catch rates will still be much less for all species than if setting had occurred in the daytime. Such instances simply highlight the need for consideration of combining other strategies with night setting for prevention of bird catch when required (e.g. appropriate line weighting, use of bird-scaring lines and bait-casting machines).

Effects on other marine species

As with any change of this nature to fishing operations, an impact on catch rates of target species and perhaps bycatch species, such as turtles, is a potential consequence. So far data from fisheries observations have been inadequate to answer such questions as whether night setting diminishes fish catch rates (Klaer & Polacheck 1995). Because the type of data currently being collected for answering such questions is likely always to be deficient an "experimental approach" has been proposed. To allay the apprehensions of fishers that night setting will affect catch rates of target and bycatch (e.g. shark) species.

To assist further in accelerating our understanding of how to maximise catch rate potential through operational change (night setting) much can be learned from appropriate integrated application of technology such as:

1. Time depth recorders (TDRs) - to measure line performance, sink rates and , set depth (Pemberton *et al* 1995)
2. Archival tags - to measure diurnal activity pattern in relation to depth of fish.
3. Hook monitors - to ascertain precisely when it is that fish strike baits.

With or without this technological proof many fishers already use night setting successfully to catch target species and to avoid birds. If research did determine that catch rates of target species decline with night setting this may simply mean that adjustments must also be made to the fishing gear and how it is used (setting depth, bait types, etc.). If night setting caused some reduction in target species catch rate, there should be opportunities in properly managed fisheries to offset this by extending the fishing season, fishing effort limits or TACs within the fixed time-frame of a prescribed fishing season.

Costs

In financial terms it is not possible to calculate the impact of a change to night setting at present. The problem is a general perception that it could only be detrimental to profitability and this may well not be the case. If it is, the cause may be easily solved (see above).

In high latitude regions, if fishing is to take place in summer then night setting may not be a feasible option (insufficient or no darkness). Consideration of alternative measures or combining seasonal closure of a fishing ground (see area closure) to allow night setting becomes relevant. But for the majority of fishing grounds there are sufficient hours of darkness in all seasons to permit maintenance of a night-setting routine. More efficient, faster setting methods then have greater appeal for prolonging the maintenance of a night-setting routine. Such methods can entail more expensive establishment or gear conversion costs. There is the question of economic viability from restricting operations to seasons when night setting can be maintained (weather unfavourable, fish absent, etc).

Most vessels have been rigged with lighting (intensity, placement) that in all probability illuminates baited hooks for birds to locate in the water astern of the vessel. Minor modifications at low cost in most instances would be adequate to remedy this problem.

A regulatory obligation to night set can compromise the fishing efficiency of smaller vessels that (due to size-related seaworthiness and catch and fuel-carrying capacity) must maximise each fishing opportunity no matter how brief this may be. And, whereas in this instance there is the option to buy a more capable vessel, economic reality, at least in the short term, dictates that an alternative of equivalent efficacy to night setting may at times have to be considered.

Whereas the cost to fishing efficiency by not having hooks in the water at the best time of the day heads the fisherman's list of reasons against night setting, others include crew safety, and the imposition to long-established traditions. Again, costs of such are incalculable but the factor of safety must itself be questioned: a day-time setting routine ensures on many vessels that up to three times more crew are at work and exposed to the more considerable hazards of night-time hauling, a situation contrary to crew safety being a realistic consideration against night-setting.

Process of adoption

Although in some fishing grounds ensuring compliance with a night-setting requirement would be feasible, in most it is not. But, unlike many other mitigation measures, night setting has the advantage in that compliance by few vessels could precipitate compliance by many. This is because of the necessity for vessels to be coordinated and cooperative when operating in the confines of fishing grounds as is often the case. A night-setting requirement could also avoid coordination problems of vessels from different nations attempting to fish together.

In the regulations pertaining to CCAMLR waters in the Southern Ocean night setting is a requirement (CCAMLR 1996) whereas in the northeastern Pacific Ocean demersal fisheries (NMFS 1997a,b) as in the draft Threat Abatement Plan for seabirds (Environment Australia 1998) it is presented as an option only.

The greatest impediment to widespread adoption is the fear of negative impact on target species catch rates and there has been no progress to settle this uncertainty or to overcome any possible impacts. Also, any impact may not be consistent between fishing grounds. Simple, universally applicable rules are most attractive. If night setting is compromised by different rules, mitigation to an acceptable level may not be attainable.

Research and development needs

1. With persistent opposition to adoption of this measure due to fear of catch-rate reduction, undertake specific research aimed at demonstrating the effectiveness of night setting for birds and for fish.
2. Use of TDRs, archival tags, hook monitors specifically to accelerate understanding of best line-setting strategy in conjunction with a night-setting routine.
3. Monitor for potential deleterious night setting consequences to bycatch. Compromising the conservation status of one species (a fish) for the sake of another (a bird) should be avoided.
4. Further improve night-setting performance by promoting the installation (for new vessels in particular) of appropriate lighting for optimum crew safety but minimum baited hook illumination, including separate light switching circuitry.

4.7 UNDERWATER SETTING

Description

There are at least four methods that have been or are being developed to set lines underwater. This is achieved in the same way by all devices, delivering baited hooks from the ship during setting so that they first emerge in the water out of sight and reach by diving seabirds. Three of the four devices are add-on attachments to the stern of a vessel, the fourth is a system of integration within the vessel's hull.

Even in their present stages of development, there would be few impediments to ensuring that these devices are suitable for vessels of all sizes. There are problems with all devices due to the gear complexities of pelagic longlining and twin line demersal operations. Considerations of this nature are described separately for each device as follows:

Mustad underwater setting funnel

This is the only underwater setting device that is at present commercially available (O. Mustad & Son, Gjovik). As an attachment to the vessel's stern for use in single line demersal fisheries this device is manoeuvred hydraulically from its stern-facing setting position to stowing position against the hull (Anon. 1997e, Figs 12 & 13). The setting pipe or funnel can be of sufficient diameter to permit the line, hooks, buoys, etc. to pass down it and exit underwater astern or have a slotted side for external deployment of buoys, weights, etc

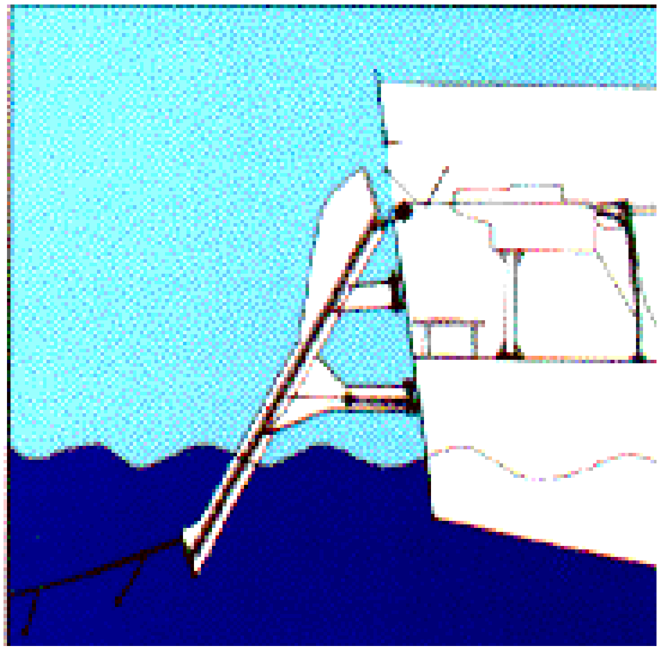

Figure 12. Mustad, stern attachment underwater setting funnel for demersal operations.

Figure 13. An underwater setting funnel, when not in use is turned and stowed against the hull

Currently, it would seem this device has some design deficiencies compromising the following essential capabilities of any underwater setting device i) to deliver hooks deep enough; ii) withstand the substantial forces acting upon it; iii) to not create additional problems, such as increased bait loss or line wear. Problems of this nature are to be expected with development of new equipment and effort is currently being directed at rectifying them. Of greatest concern is the uncertainty as to whether it is possible to use such a concept (in an engineering sense) to set hooks deep enough to avoid birds in all weather conditions. In its present form it delivers baits only about 1.5 m below the surface in calm seas, insufficient considering the potential sink rate of this gear, the reduction in setting depth in rough seas and seabird diving abilities, especially in the Southern Ocean where pursuit divers, such as the White-chinned Petrel, are commonly caught on longlines.

Underwater setting chute

A device that is now well advanced in development and performance assessment by New Zealand (Department of Conservation, fishing industry and private engineering consultants). Although similar to the previous device, the chute system (Barnes & Walshe 1997, Fig. 14) is considerably different in that it has the potential to be applied to demersal as well as pelagic operations. This is because the small-diameter pipe is not fully rounded, having a continuous slot along its entire length. This provides the opportunity if needed for externally deploying radio beacons, line floats, weights, etc. while the line and hooks attached remain within the chute (demersal gear). Or, conversely the only items to travel within the slotted pipe would be the baited hooks (pelagic gear). Also, the chute system relies upon being withdrawn from the water when not in use because it is flexibly mounted, unlike the pipe system. This is a feature of great relevance to stress considerations associated with hanging comparatively fragile items off big ships in rough weather.

To achieve and maintain its setting depth of three metres the chute system relies upon a winch/paravane mechanism. A combination of water injection and venturi force accelerate baited hook passage down the chute. Conceivably it would be possible to ensure rapid, simple chute withdrawal, a facility essential to cope with unexpected events such as main line jamming that necessitates rapid vessel manoeuvring. Overall the chute is a device with considerable potential and like the pipe system is attractive in its simplicity.

Hull integrated underwater setting systems

Although several companies in Australia, and perhaps elsewhere, are pursuing this modification for existing vessels or for incorporation into new vessel design and construction, the system remains a concept only. And, whereas this may ultimately be the most efficient, cost-effective and successful means of all to mitigate bird problems (particularly with new ship construction) this will never be determined with certainty until it is tried, which will entail radical vessel redesign. Consequently, there has been reluctance or insufficient incentive for a prospective developer to carry out the modification.

Figure 14. Underwater setting chute (New Zealand development system)

An integrated underwater setting system would entail the construction of a tunnel through the ship that emerges at or near the keel (Gorman 1996, Fig. 15). Greater depth and propeller clearance could be attained with a telescopic extension). It is perhaps too costly as a modification for existing vessels but not in new vessel construction, with the added advantage of the potential to combine the space needed for line hauling with that for line setting. Alternatively, a slotted hull section within or added to the side of the hull leading aft and downward (not unlike a chute system but as part of the hull itself) could be constructed. This concept would better suit modification of existing vessels at lower cost.

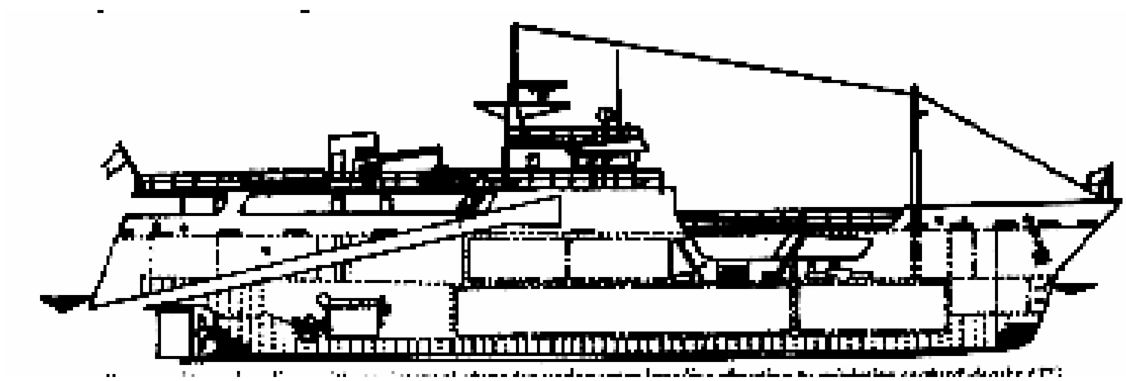

Figure 15. Illustration of a hull integrated concept for underwater setting (from Gorman 1996)

Underwater setting capsule

Unlike the previous three systems that use a passive means of transporting baited hooks underwater, this one is an active system. The baited hook is transported within a retrievable capsule to a predetermined depth where it is released (Smith & Bentley 1997, Fig. 16). Suitable only for pelagic systems, it has the added advantage of being compact and easily fitted to any size vessel, irrespective of associated gear configuration but has potential disadvantages inherent in any equipment with many moving parts. Also, the depth to which it can deliver baits is more versatile than the previous systems (but nevertheless regulated by cycle time demands that are unavoidably related to fishing effort from hook distance interval and vessel speed). A working prototype is at present being re-engineered and is ultimately envisaged to be electronically controlled and include a performance-monitoring capability (Smith & Bentley 1997).

History

The Mustad underwater setting pipe has been available commercially for several years. O. Mustad & Son now the patent holders, market the device world-wide and are considering redevelopments (Anon. 1997a).

The chute and the capsule are concepts for development that were inspired by the Department of Conservation (DOC) of New Zealand in collaboration (and with financial input) with the New Zealand fishing industry. Both devices are at present undergoing development to meet operational requirements unless, in the process it is revealed that this is not achievable. Several 'public' demonstrations of prototype devices in operation have already occurred, the most recent in late 1997. Developmental work is now being funded jointly from New Zealand and Australian government sources.

Effectiveness

The only underwater setting device in commercial use which has been evaluated for its contribution to reducing seabird mortality is the Mustad funnel (Løkkeborg 1996, 1997). This assessment indicated that although a significant reduction in bird catch rate could be achieved (see section 3) a large number of birds can still be caught. It must not be assumed from this that underwater setting as a mitigation device is inadequate, but that further development is required, especially as the above study only involved the Northern Fulmar, largely a surface feeder. A proportion of the bird catch reduction achieved was perhaps not so much a product of underwater setting but of reducing the time (and distance) taken for hooks to get into the water and commence sinking. Because seabird species vary considerably in their diving capacity, and fishing grounds may only have certain species present, the capabilities of underwater setting devices need not be identical to achieve similar levels of effectiveness. Further tests are planned (E. Dunn, S. Løkkeborg, P.G. Ryan & C. Steel *in litt.*).

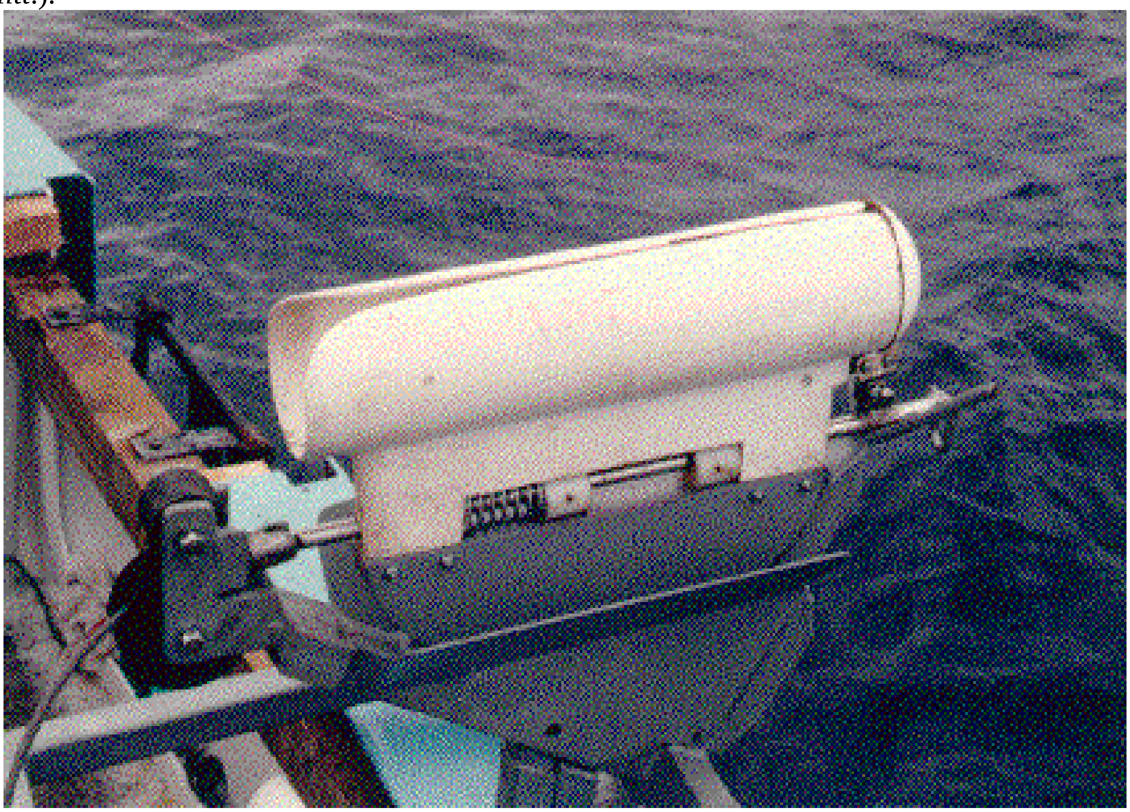

Figure 16. Underwater setting capsule (New Zealand development system) ready for launching on its retrieval cable off the mounting rack at stern rail of pelagic longliner

There are two factors that may influence effectiveness: i) the influence of propeller turbulence on bait retention if bait enters the water immediately astern; and ii) how far underwater it is that baits need to be released before all or most birds cannot get them (three metres is here assumed to be adequate).

The reality of underwater setting is that of all known mitigation measures it is, on its own and irrespective of concurrent use of other measures, the only one with the potential to avoid incidental catch of seabirds, to have no deleterious consequences (save perhaps for enhanced bait loss) and require no monitoring or compliance processes to ensure its use. However, economics and the time involved for development and widespread use indicate that other measures must be adopted in the interim. There is a need for protection of seabirds while more expensive but better technology (perhaps not even underwater setting) become available and in common use. Ships equipped with the latest capabilities can take many years to saturate all fisheries, including the ones least able or inclined to afford interim measures to reduce bird problems.

Effects on other marine species

Less bait lost to birds should lead to higher catches and increased profitability.

Costs

Precise figures are unavailable and will vary considerably depending on the type of setting device, and whether it is to be fitted to a new or an old vessel. Cost-effective devices should only be an outcome expected from well funded research and development initiatives exploring the many options of underwater setting concepts.

Process of adoption

On the assumption that underwater setting devices will be successfully developed, this improved method of fishing is most likely to be automatically adopted by fisheries over time. Accelerating this adoption process can be achieved by consideration of using such incentives as preferential licensing for those that have such capability (remembering here that other mitigation strategies may prove equally effective).

Research and development needs

i) Funds provided to assist in any vessel conversions or gear developments in order to accelerate learning of the full potential of this mitigation measure.
ii) Incentive offer such as licensing preference to promote use.
iii) Vessel builders and gear manufacturers - development prize incentive offer to attract interest.

4.8 LINE WEIGHTING

Description

Because the hooks that are set by most vessels in all longline fisheries commence their descent from the sea surface, each one is potentially available to birds. It is the amount of time that a baited hook remains near the sea surface or how fast it is sinking that determines the likelihood of it being taken. If the position and amount of weight on lines were correct, bird problems could be largely avoided in all longline fisheries (e.g. Brothers 1995b).

Precisely how fast a bait needs to sink (the faster the better) so that birds cannot take it is governed by three factors: i) whether additional bait protection such as a bird-scaring line is being used; ii) the vessels' line-setting speed; and iii) the foraging capabilities of the seabirds present. A vessel setting at three knots provides a baited hook with protection for longer than does one setting at 10 knots and so can afford to have slower sinking baits.

Foraging capabilities of seabird species vary. Some are only capable of surface feeding. Some have poor diving capability (to about one metre) and others are proficient divers (to 20 m or more but still largely reliant upon visual detectability from the surface so sink rate of baits is still critical). To account for these variables and to achieve consistent, reliable benefit from appropriate line weighting necessitates a generalized approach - the faster the better by putting on the line as much weight as often as possible within the limits of feasibility. How this can be done is different in each of the longline fisheries according to the method and gear used.

Pelagic longlining

Pelagic longlines are usually unweighted or weighted 7-10 m from the hook with a 30-80-g swivel. Brothers (1995b) showed by sink-rate measurements that 70 g at this distance was desirable. Unweighted hooks sink too slowly and the addition of a 20-g weight at or near the hook can almost double the sink rate to 0.5 m/s (Brothers 1995b, Pemberton *et al.*1995). Vessels are known to use successfully (in terms of target species catch rates) fixed or free-moving lead sinkers of either 10 g or 20 g at the hook and others to use up to 80 g five metres from the hook (Duckworth & Wells 1995, Figs 17 & 18). To date, the amount and position of weights used has been determined by fishers' perceptions of:

a) line sinking characteristics and propensity to tangle.
b) bait attractiveness to target species - more visible due to proximity of a swivel (for example), motionless or moving because of attached weight.
c) attaining and remaining at (or near) the target hook depth.
d) gear loss cost (more weighted swivels, more cost).
e) logistic complications of a heavy object (e.g. in situation of snood bin use where tangling rate can be exacerbated).
f) crew safety aspects.

Appropriate line weighting is particularly important with monofilament lines, otherwise three to seven times more birds may be killed (Brothers *et al.* submitted ms). Although 200-g lead sinkers are used regularly along monofilament lines their position on the main line (up to 40 m from the nearest hook and perhaps 200 m from the most distant hook) is of little consequence to hook sink rate and bird problems. In fisheries where monofilament line and light gear are extensively used lack of any line weight can cause problems to birds but is also likely to affect fish catches because hooks do not maintain desired setting depths. It is also important whether the weights (swivels, etc.) that help to sink the baited hooks are thrown into the water before or after the bait. If after, then affect on bait sink rate will be slowed and the farther weights are from hooks the slower.

Demersal longlining

In demersal longlining the consequence of weighting lines is totally different to that in pelagic operations. Because demersal gear actually sets on the ocean floor, in theory the only limitations on attaching weights is hydraulic hauler capacity and the method of weight attachment and detachment. There is an incentive to attach additional weights to reduce descent time where the ocean floor can be up to 2500 m away. Weights additional to the actual line mass are not always used to accelerate sink rates and if they are, not with consideration to reducing bird catch. The additional advantage in demersal longlining is that snoods or branch lines (the line that attaches each hook to the main line) are generally less than 1 metre in length so irrespective of where a weight is attached it will have an immediate impact on hook sink rate (provided the distance between each weight is not too great). An investigation of appropriate line weighting in the Spanish twin line system (Brothers 1995a) prescribed attachment of 6-kg weights at 20-m intervals (Figs 19 & 20). Regardless of how heavy or how frequently attached, weights must be pushed from the vessel to avoid line tension astern exposing hooks to birds for longer.

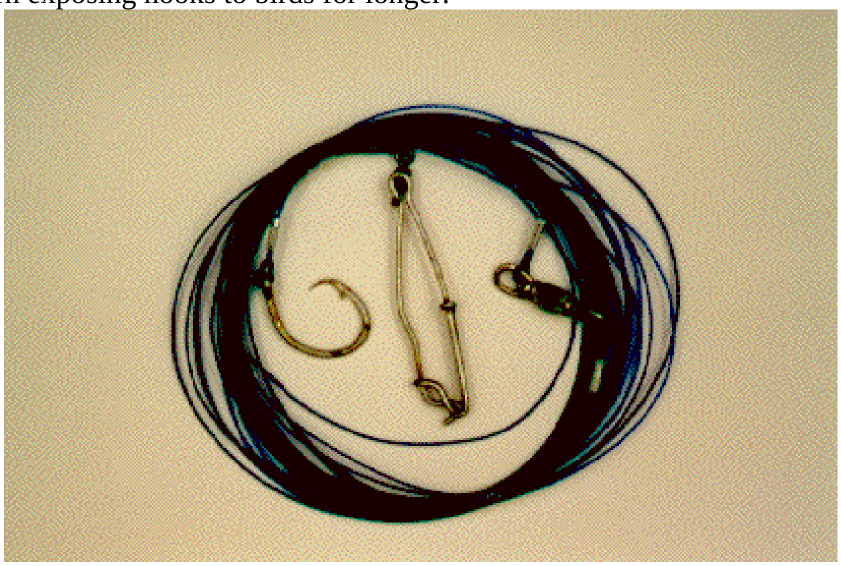

Figure 17. Pelagic longline fishery branch line with a clip and 80 g swivel, 5m from a heavy hook, contributing to rapid sink rate (FV "Kariqa", M. Wells New Zealand)

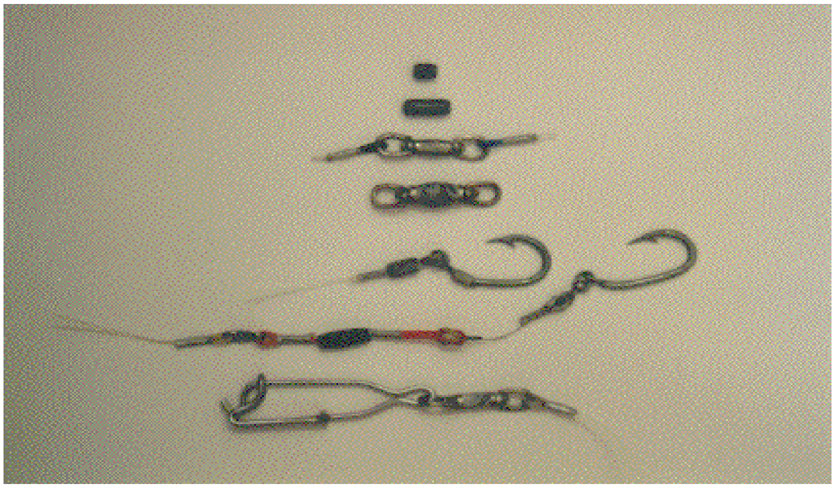

Figure 18. **A variety of weighted gear used in pelagic fisheries to increase sinking rates of hooks (80g, 38g, 20g and 10g weights are illustrated)**

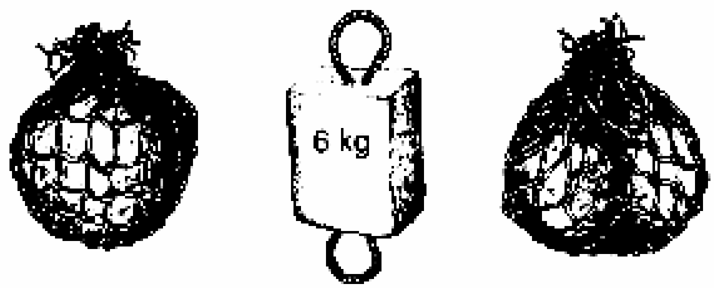

Figure 19. **Recommended weights for twin line demersal longlines**

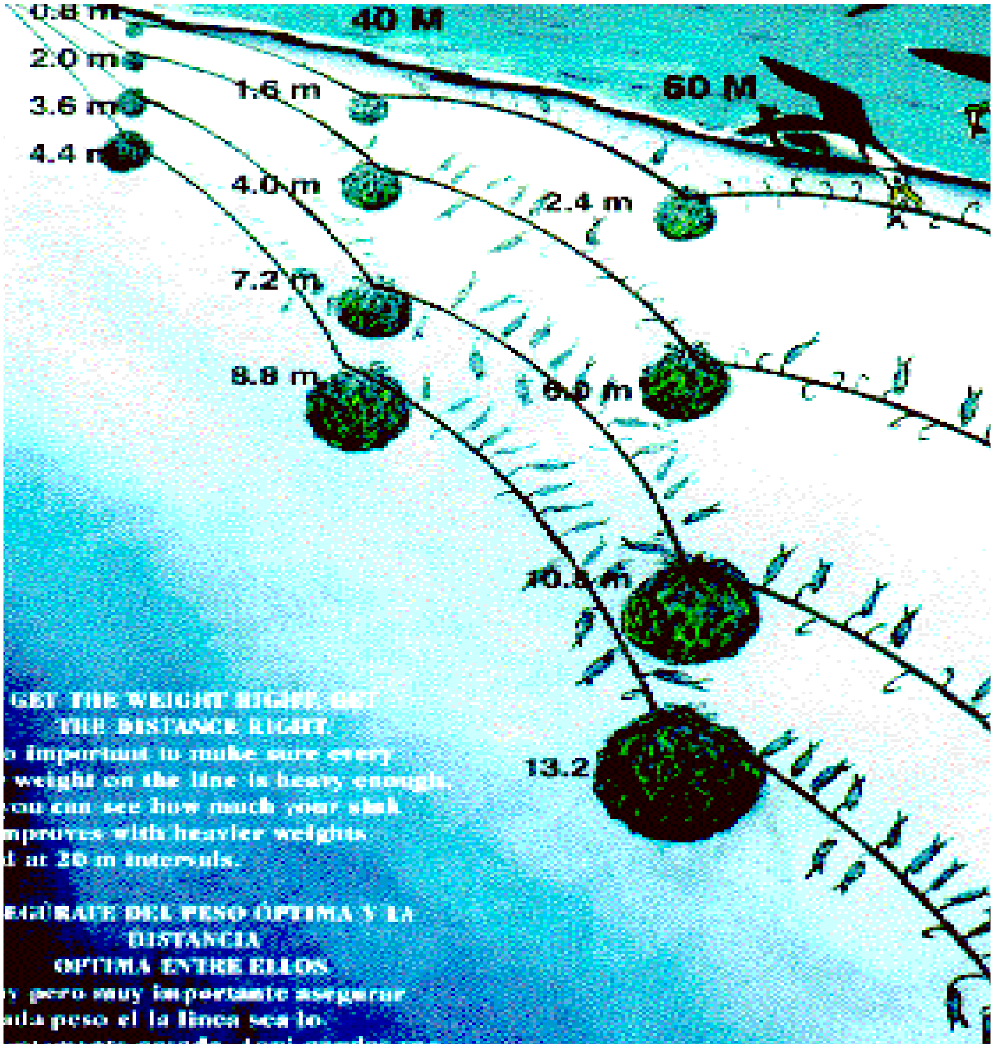

Figure 20. **Illustrating the benefit to line sink rate from weight increase in demersal longline fisheries**

Unlike the above twin-line system in which deliberately buoyant lines are used and therefore must essentially be weighted so they sink, the single line systems such as the Mustad Autoline use negatively buoyant line material. Because this inbuilt sinking capability is limited and there are practical complications to adding more weight (F. Pedersen *in litt.*), bird problem potential is high (contrary to Gorman 1996). In fact, the sink rate by this system (for 7-mm diameter line) has been measured to be alarmingly slow, with baits accessible to birds for more than 25 s after being set (N.P. Brothers & W. Baker unpubl. data). There are no solutions available at present to overcome this deficiency despite commercially available weighted line material being available (F. Pedersen *in litt.*).. Other solutions such as underwater setting may ultimately prove more acceptable or feasible than increasing line sink rate in autolining.

To complicate matters more, in both single and twin-line demersal systems line buoyancy is radically increased when line floats are used to alter setting characteristics for targeting certain species. The sink rate influence of line floats has been measured (N.P. Brothers & W. Baker unpubl. data) on a 7-mm diameter, single line system with 3 kg of buoyancy floats. Hooks remained within two metres of the surface for five minutes, ideal for catching large numbers of birds. Increasing sink rate by adding weights would simply defeat the purpose of the line float. So, the only option to overcome this is for the lines attaching floats to the hook line to be a minimum of three metres in length (they are usually only one metre or less in length). This will ensure that hooks descend unimpeded to avoid bird problems in the critical first three metres.

For other methods of demersal longlining such as trot-lines, drop lines and the more conventional single or twin-line systems using automated or manual baiting, similar attention to appropriate weighting can virtually eliminate bird problems encountered during line setting.

History

Although no observations describing the nature of seabird interactions in longline fisheries 20 or 30 years ago exist, it is likely that the factor of sink rate was not then so acute. This is because gear, in the past was heavier. More sophisticated metal use has produced stronger but lighter hooks, heavy wire hook traces have been replaced by light monofilament line; line manufacturing technology has pursued strength increase with material weight decrease (from multi-strand, heavy natural fibre line to synthetic multi strand to single strand light synthetic materials). Also driving these changes has been the economics of balancing actual material cost with its durability and increased catch rate, irrespective of any associated problems such as catching more birds.

In 1988 Brothers (1991) advocated appropriate line weighting for pelagic longlining. Ashford *et al.* (1995) and Barnes *et al.* (1997) identified this to be important in demersal fisheries using twin-line systems. After investigating the potential of using an appropriate amount of weight at optimum spacing to prevent seabird deaths in fisheries using this line system (Brothers 1995c), CCAMLR recommended the findings to fishers in 1996 and formalised these by regulation in 1997 CCAMLR Conservation Measure 29/XVI). The U.S. National Marine Fisheries Service has also incorporated line weighting in its regulations for its Pacific groundfish fishery (NMFS 1997a,b). The draft Threat Abatement Plan (Environment Australia 1998) provides for selection of appropriate line weighting as a mitigation measure option in the Australian Fishing Zone.

Effectiveness

Although bird problems could be largely overcome by weighting lines adequately, there are few data to substantiate this A strong inverse relationship was found between weight and bird catch rate in twin-line demersal fishing (Brothers 1995a). And, in pelagic fishing three to seven times more birds may be caught on lighter gear (Brothers *et al.* submitted ms).

Differences of opinion regarding how much weight and where it should be placed will influence effectiveness and may dictate that to achieve desired levels of bird mortality reduction, combining with other mitigation measures (e.g. use of a bird-scaring line) may be essential.

Certainly, catch rate assessment is urgently required to measure the effectiveness of the line weighting prescriptions that are being promoted (Brothers 1996) and considerable scope for further refinement to improve the effectiveness of this measure remains (see research and development needs).

Effects on other marine species

Although no studies have yet been undertaken, alterations such as making fishing gear heavier has the potential to change catch rates of both target and bycatch species. Preliminary results of measuring the effect of line weighting on seabird catch rates in a pelagic fishery do however suggest that a significant reduction occurs. And, owing to the indication from TDR measurements that hooks may not set at the optimum depth to catch fish if unweighted (N.P. Brothers unpubl. data) it is not surprising that the same preliminary data suggest catch rates of tuna are higher on weighted lines (Brothers *et al.* 1998).

However, there is perhaps a conservation dilemma over the weight of lines used. Y. Kawai (pers. comm.) reports that in some pelagic longline fishing grounds turtles drown when they are pulled under by longlines made from heavy materials, so in these fishing grounds there is an incentive to use light lines. The same vessels are likely to fish elsewhere where turtles do not occur but seabirds do. In fact seabirds when caught on light longlines are often retrieved alive, although the lighter lines are capable of catching and killing more birds (Brothers *et al.* submitted ms).

Costs

Many fishers believe that the cost of using more heavily weighted lines is lost fishing efficiency. Not all fishers subscribe to this belief because appropriately weighted lines are already successfully used.

In pelagic longlining how much weight, how it is attached and where it is in relation to the hook is an important cost consideration. If attached adjacent to the hook then loss rate of weights can be high when lines are inadvertently cut by bycatch (especially sharks). The same applies if free-sliding sinkers are used. The cost significance of these losses must of course be considered with respect to increasing target species catch rates by preventing bait loss to birds. It would take the loss of considerable quantities of lead centre swivels (for example), to equal the value of just one more tuna caught.

In demersal longlining the consequence of appropriate line weighting on costs is not so uncertain. There do not appear to be concerns about target species catch rate reduction potential; in fact heavier lines are thought by some to catch more fish because more hooks actually remain on the ocean floor where the fish occur (most pertinent in twin-line system).

There have been concerns over the dangers to crew of weighted lines. In all probability the risk is likely to be greatest if a branch line (pelagic gear) under tension suddenly falls slack (e.g. a shark severs the line) when being hauled aboard. A New Zealand fisher has been killed by a heavy lead centre swivel (J. Molloy pers. comm.). But, not forgetting fishers are killed by many means in their occupation, prescribing weighted lines may have a legal cost consequence. The crew safety aspect of weighted lines must not be ignored as it alone can determine use by some fishers.

Process of adoption

If fishing gear changes of this nature were prescribed in regulations then the logistic difficulties for fishers not complying would be a lot more obvious (and therefore compliance more likely) than for other potential mitigation measures. Irrespective of this, considerable potential yet remains in the area of experimentation and evaluation to demonstrate the advantages of weighting lines. This should lead to willing compliance accelerated by appropriate education/promotion. So far, line weighting has become an established regulatory requirement in two demersal fisheries and is proposed for one pelagic fishery (see history section).

Research and development needs

1. Further evaluation of line weighting benefits, including where and how much weight for optimum performance (some ongoing research by the Tasmanian Parks & Wildlife Service).
2. Urgent attention required by fishing equipment manufacturers for autoline system sink rate improvement
3. Evaluation of crew safety consideration: is more weight more dangerous; does how and where a weight is attached determine its lethal potential; some fishermen use protective head gear and face shields against hooks mostly - are there other risk reduction devices?
4. Existing statistics on vessel performance (catch rates) in relation to gear configuration (how much weight and where it is in relation to the hook) need to be analysed.
5. Promotion of appropriate line-weighting procedures and their benefits.

4.9 BAIT CONDITION

Description

There are two features of a bait that can affect its buoyancy and therefore its availability to birds. A frozen bait will float or sink slowly as will one that has sufficient air retained in its swim bladder (Brothers *et al*. 1995, Fig. 21). With the exception of those fisheries in which artificial lures or live baits are used, all longline bait is stored frozen and may or may not be used on hooks in this state deliberately, or accidentally. The proportion of bait fish used that has sufficient air retained in swim bladders so that they float is highly variable. One reason is because this problem is, to a certain extent species specific i.e. more prevalent in certain bait species (Brothers *et al.* 1995).

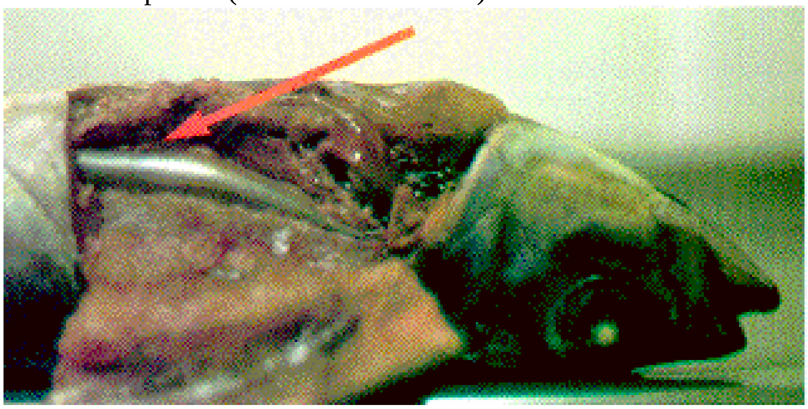

Figure 21. A bait fish dissected to expose its unpunctured swim bladder

For pelagic longlining each hook is manually baited with a whole fish such as a pilchard, sardine, mackerel or squid and then thrown to port or starboard clear of the ship's stern. The line to the hook is used to swing the bait to a preferred distance away from the vessel which can jeopardise bait retention on the hook, more-so if the bait is soft rather than frozen or partially thawed. There is thus an incentive to use frozen bait to avoid such loss but as a result equivalent or greater losses then occur to birds as these baits float for longer astern.

Although hooks weighing 20 g are most commonly used, 10-g hooks are also used in pelagic longlining with usually no other additional weight used near the hook. Therefore frozen baits and baits similarly buoyant because they have air retained in swim bladders are at greater risk of being taken by a bird.

Generally, it would seem fishermen remain ignorant or indifferent to the importance of bait condition in relation to bird problems or general fishing efficiency and their daily operations are characterised by a highly variable bait state. This may be driven by the following:

a) removal of bait from freezers prior to line setting is often inadequate. It is also unrelated to bait-thawing facilities being available and thaw factors such as air temperature.
b) lack of consistent attention to bait thawing during each line setting - thawed baits and frozen baits get used indiscriminately.

c) frozen baits are difficult to apply to hooks and when they are, the hook can withdraw easily i.e. incentive to thaw.
d) thawed baits pull off hooks more easily when they are thrown from the ship ie. incentive to keep frozen.
e) those crew actually applying baits to hooks find discomfort in having to persistently handle frozen bait i.e. some incentive to thaw.
f) inadequate thawing facilities discourage crew to be thorough and consistent.
g) on many vessels 15 or more individuals are on separate occasions responsible for bait thawing which leads to inconsistencies (more problems educating).
h) last-minute bait quantity short-fall during setting is met by using more, direct from freezers.

The most significant finding of the study by Brothers *et al.* (1995) was that regardless of whether a bait was thawed it may still sink too slowly because of air in the swim bladder. Adding as little as 20 g (lead sinker or swivel for example) to a baited hook can significantly increase its sink rate.

These same features of a bait that affect its sink rate have considerably different potential to affect bird catch rates in demersal longlining. For demersal longlining using the autoline method whole baits must first be at least part-thawed before it is possible for them to be sliced into sections by the automated baiting system. With other demersal fishing methods, whole fish in varying state of thaw (difficult to control where the air temperature can be at or below zero) and baits with swim bladder intact are used, yet the associated problems are overcome by the line sink rate due to regularly attached weights. Further, the time interval between hook baiting and hook setting where baits are manually applied to hooks (e.g. Spanish twin-line system) is unavoidably long enough to ensure thawing is complete, unless prevented by very low air temperatures.

History

1988 First identified as an important factor contributing to the availability of baited hooks to birds in pelagic longlining for tuna in reports to CCSBT and CCAMLR (Brothers 1988, 1991) and promoted as a mitigation measure for pelagic longline operations by Brothers (1994a, 1995b, 1996).
1991 CCAMLR regulations prescribed thawed bait use.
1995 Investigations that attempted to define the degree of influence thawed state and swim bladder in various bait species have on sink rates (Brothers *et al.* 1995).
1997 NMFS prescribes thawing bait and/or weighting guidelines so that baited hooks sink as they are put in the water (NMFS 1997a,b).

Effectiveness

Three studies have examined the potential benefit of using thawed bait in pelagic longline fisheries. None has addressed the additional complication of swim bladders contributing to a reduction in bait sink rate and so the assessments of thawed bait remain flawed. Duckworth (1995) reported a 69% reduction in catch rates when thawed baits rather than frozen baits were used, Klaer & Polacheck (1995) and Brothers *et al.* (submitted ms) also found that using thawed bait decreased seabird catch in summer. Data deficiencies preclude any determination from records of observations of fishing during winter (and also limits the usefulness of the summer assessments too because of poor data collection protocols, discussed in Brothers *et al.* (submitted ms). The frozen bait catch rate was 1.13 birds/1000 hooks, fairly thawed 0.63 and well thawed 0.27 birds/1000 hooks (Brothers *et al.* submitted ms). Although thawing bait and puncturing swim bladders has benefits, the same effect can be achieved by adding line weights (Brothers *et al.* 1995). Bait thawing in demersal longline fisheries is not considered necessary (Brothers 1995a).

Effects on other marine species

None known.

Costs

To a fisher who believes that using thawed bait increases bait loss there is the reduction in fishing potential to consider. Convincing otherwise is not necessarily achievable but the option exists to use a bait-casting machine (BCM) with thawed bait and not increase loss rate or reduce throwing efficiency . Alternatively, a fisher who considers frozen bait is best must consider the necessity to overcome slow sink rate by adding appropriate weight, which bears a cost.) The use of inexpensive purpose-built bait thawing racks incorporatimg a sprinkler system has been advocated (Brothers 1995b, 1996, Fig. 22). On vessels where space permits, such a system can ensure all baits are treated appropriately with minimum effort by crew.

Using added weight near each hook to counteract the buoyant effect of swim bladders in bait is applicable. Expelling air from baits by use of a spiking device used concurrent with hook attachment and air evacuation during bait packaging are uncosted concepts.

The possibility that the swim bladder problem is more prevalent in certain bait species is suspected (Brothers *et al.* 1995) but requires further investigation.

Process of adoption

The only fisheries which make reference in their regulations to the importance of thawing bait are the demersal fishery of the Southern Ocean (CCAMLR Conservation Measure 29/XVI) and the US groundfish and Pacific Halibut fisheries (NMFS 1997a,b) which note both weighting lines and thawing bait as measures to increase the sink rate of baited hooks.

In its draft Threat Abatement Plan (Environment Australia 1998) Australia proposes a combination of the following measures:

- use lines which are sufficiently weighted.
- demonstrate an ability to thaw baits before lines are set.
- use thawed baits on hooks.

In pelagic longlining baits tend to sink too slowly irrespective of thaw state or swim bladder inflation. Although attention to thaw state and swim bladders will greatly reduce the likelihood of baits being taken by a bird, advocating this degree of fine-tuning in longline fisheries for mitigation is of limited value unless bait sink rates are generally improved and other appropriate measures (such as bird lines) are also employed. It remains to be seen whether such measures in combination will actually be used and if so whether their bird mortality reduction capacity is great enough. To facilitate this by regulatory processes has obvious limitations or uncertainties as does using voluntary adoption for which education would play an important part.

Figure 22. Bait rack and water sprinkler system for efficient bait thawing.

Research and development needs

1. Examine the potential for removal of air from bait fish swim bladders during bait-packaging procedures.
2. Evaluate mechanisms for expulsion of swim bladder air from bait at the hook-baiting stage.
3. Hook sink rate improvements.
4. Ship builders and fishing equipment manufacturers to take account of the necessity for suitability appointed bait-thawing racks on all vessels.
5. Education material, crew-awareness training.

4.10 BIRD-SCARING LINES

Description

A bird-scaring line (BSL) is here defined as any device that when deployed astern during line setting deters birds from taking baited hooks. BSLs are either lines with suspended streamers, as used in tuna longline and demersal fisheries in the Southern Hemisphere, or towed objects such a "buoy bags", as used in the Alaskan fisheries (e.g. Anon. 1991, Brothers 1994b, 1996, CCAMLR 1996, NMFS 1997a,b).

With the recommended and commonly used streamer BSL (Brothers 1994b, Fig. 23), a mounting pole on the vessel's stern should be used to gain sufficient height above the sea surface. The higher the mounting position, the greater the distance of bait protection. It is important to minimise the need for bait protection over a great distance by appropriate hook-line weighting. Correct height also prevents the fishing longline interfering with the bird line. The mounting position must ensure that the bird line with streamers attached is towed astern directly above the area where baits enter the water (Fig. 23). Construction materials are very important to operating efficiency. Appropriate materials will help prevent birds becoming used to a BSL, reduce line stress on the pole, cross wind effects, tangles with fishing gear and also make setting and retrieval easier. Japanese fishers used these principles to design their pole and line design ("tori" poles) for pelagic longlining.

Tension is required to keep a BSL correctly positioned, irrespective of weather conditions, best done by line drag alone, which can be increased by using larger diameter line from aft of the point where the BSL enters the water (about 100 m if mounting height is adequate). If line retrieval is mechanised by use of a hydraulic or electric winch (Fig 24) it no longer matters how much line is needed to produce the correct amount of drag. In demersal fisheries the usually central line-setting position makes the deployment of two BSLs feasible (Fig. 25).

History

Prior to 1988, the year in which the usefulness of BSLs for reducing bird mortality was first documented (Brothers 1991) small numbers of Japanese pelagic longliners were using this system to reduce bait loss. Already BSLs had become quite sophisticated and in the ensuing six years the effectiveness of this style of line or variations on it were noted. During this period and more recently deploying BSLs has been made compulsory in some fisheries. Its popularity (as a measure to prescribe) most likely stemmed from the fact that, of all mitigation devices BSLs were seen to be least likely to disrupt or antagonise fishers.

Effectiveness

The overall effectiveness of BSLs for reducing seabird catch rates and the degree to which different attributes may affect BSL performance have been discussed in detail (Brothers *et al* submitted ms). It should be noted that catch rate reduction is not the same as bait loss reduction which has seldom been quantified (see Brothers 1991, Løkkeborg & Bjordal 1992a,b). Considering all sources of catch rate assessment, BSL can reduce bird mortality by between 30% to 70% in pelagic longline fisheries (Brothers 1991, Klaer & Polacheck 1995). But, in most instances these estimates are conservative because inferior BSLs are often used. Brothers *et al* (submitted ms) highlights the need for careful thinking if BSLs are to be effective, and the importance of not solely relying on statistical analyses of data to interpret mitigation performance. Other studies have also emphasised the importance of a satisfactory BSL design (e.g. Ashford *et al.*1995, Duckworth 1995).

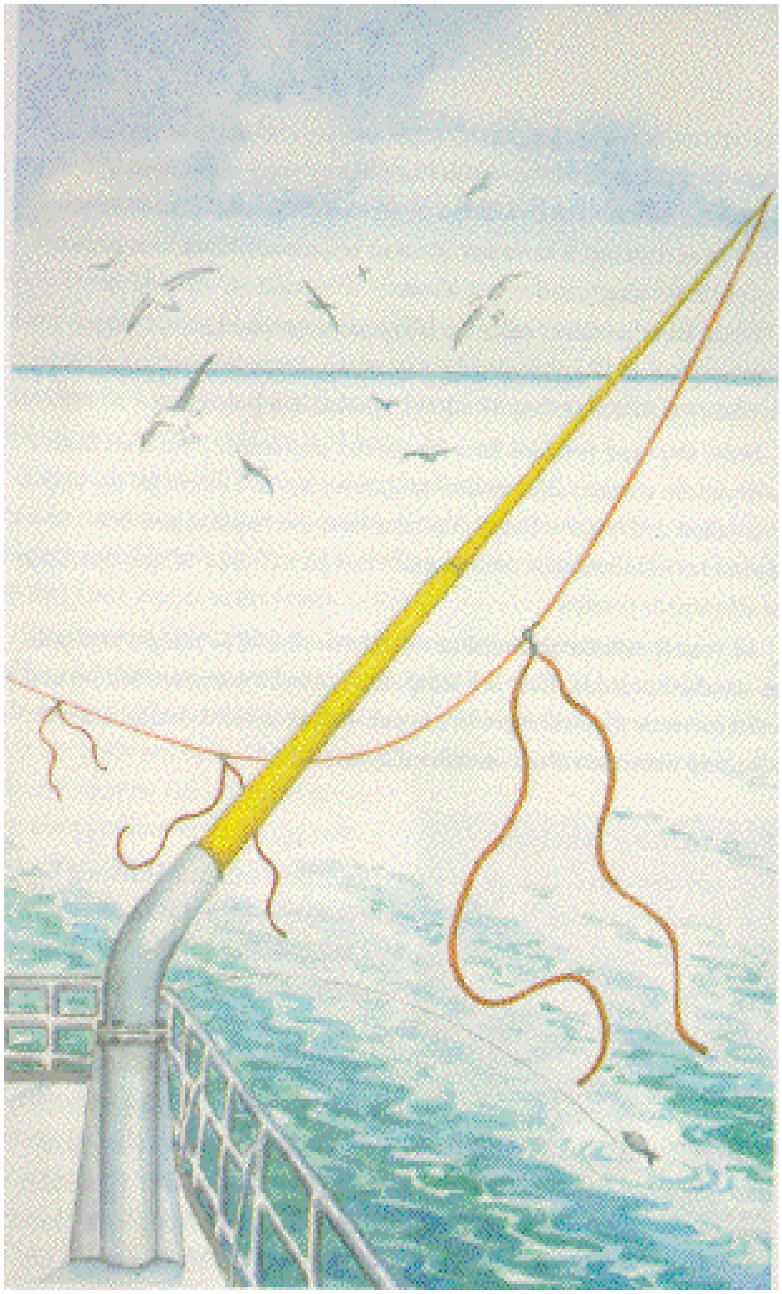

Figure 23. A bird line in use on a pelagic longline vessel, the pole keeping streamers over the position to where baited hooks are thrown

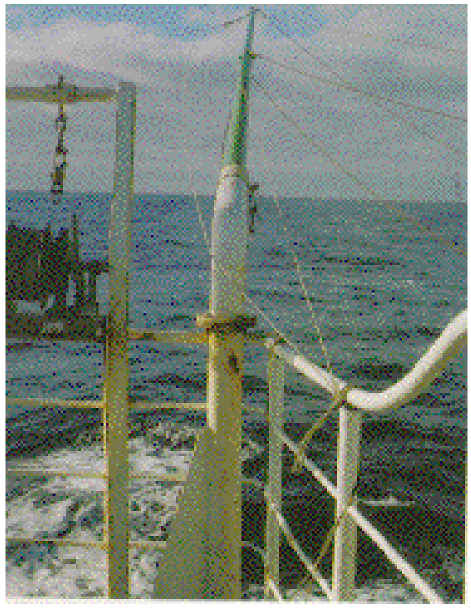

Figure 24. BSL pole with setting and retrieval winch alongside for maximum efficiency

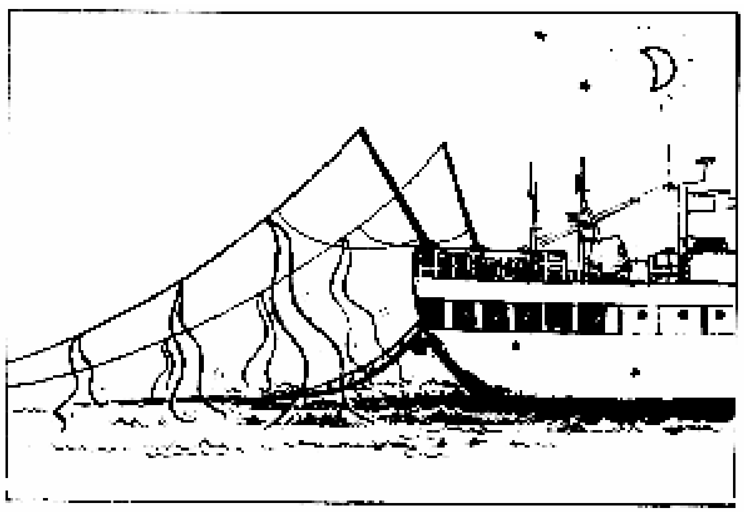

Figure 25. For demersal operations, a twin-line system of BSL for maximum protection

It is more difficult for a BSL to be as effective in pelagic compared to demersal longline fisheries. Baited hooks in pelagic fisheries generally sink more slowly and are thus exposed to birds for longer and because these are on long branch lines thrown away from the vessel it is more difficult to protect them with a BSL. So it is not surprising that Løkkeborg (1996) reports a higher protection potential in a demersal fishery (90-98%). Ashford *et al.* (1994) and Moreno *et al.* (1996) also report catch rate reduction by by use of BSLs in demersal longliner fisheries. The aspects of demersal operations that are different to pelagic provide for the opportunity to use BSL designs with even greater bait protection ability. For example, the capacity to use not one but two lines (Brothers 1996). Shorter BSLs may be used successfully because baits can be made to sink faster. Attention to hook sink rate therefore has considerable influence upon BSL design requirements.

The use of a bait-casting machine (BCM) can take advantage of a two BSL system because the versatility of bait throwing direction is utilised to further reduce bird interference (see below). In addition, the consistently accurate bait throwing capacity of a BCM also improves BSL performance because all baits can be placed under the BSL.

Different species of seabirds respond to BSL differently (Brothers 1991), a consequence of their varying agility, search pattern in relation to proximity of the vessel, diving performance and interspecific aggression. So, bait protection against some species is not so effective. This may vary seasonally in a fishing ground or differ between fishing grounds and be influenced by species composition and abundance.

Weather conditions also influence the effectiveness of BSL, particularly wind direction and speed in relation to line setting course. This influence is an important factor determining most appropriate BSL material to minimise deflection by wind but with consideration to line strength and the preference for a less conspicuous (habituation factor) line.

Previously mentioned was variety of opinion on line design. Effectiveness in terms of catch rate reduction potential and suitability to operational factors (vessel size, setting speed) seem to be the chief concerns. It will however take a long time to measure the effectiveness of all BSL designs because of the complications already discussed pertaining to the variables and interaction of variables influencing catch rates, compounded further by habituation over time to variations on the same device.

Effects on other marine species

Use of BSLs can increase fish catch by reducing bait loss, valued at A$4.9 million annually in one pelagic fishery (Brothers 1991). Bait loss can also be of economic importance in demersal fisheries with up to 445 baits lost to birds from one line set (Brothers 1995a).

Costs

Materials most suitable for constructing BSLs (Brothers 1995a, 1996) may not be readily available on all vessels, requiring their purchase. Commercially-produced BSLs range in cost from $A200-300. Commercial availability may displace the current trend of constructing lines from less-suitable materials such as longlines and plastic packaging straps from bait boxes. BSLs wear out and can be inadvertently cut during fishing so spares should be carried.

A further expense associated with BSL is the mounting (“tori”) pole. Style and materials are highly variable but Japanese vessels prefer commercially-available telescopic 11-metre trolling poles made of fibreglass which cost around A$1100. To avoid this cost longline vessels should be constructed with mounting poles. Installation of a setting and retrieval winch (Fig. 26) also entails a cost.

Process of adoption

There are now six separate regulatory processes in which BSL use is prescribed and in a number of other fisheries use is highly recommended. In Australia the use of BSLs has been a highly recommended measure for saving bait and birds since 1988. Prior to this, profitability of fishing, not saving birds, was probably the only motivation and use was confined to days of severe bait loss to birds. Despite being only a recommendation, Japanese vessels fishing not only in the Australian Fishing Zone but also on the high seas progressively adopted this measure. From 1988 to 1995 the number of Japanese vessels in Australian waters carrying bird poles and streamer lines increased, from one to all ships. Of the seventeen vessels whose fishing operations were observed (Australian Fishing Management Authority observer programme) all used BSLs in 1995. However, characteristics of lines and poles on vessels indicated that equipment quality and use was inadequate. These deficiencies were comparatively minor problems compared to lack of any progress with pole and line use to avoid catching seabirds by Australian domestic longliners even by 1995. The introduction in 1996 of mandatory use of BSLs in the Australian Fishing Zone for all vessels fishing south of 30^{o}S (Australian Fishing Management Authority regulations) led to efforts to ensure vessels were properly equipped, including port visits by Japanese Tuna Fisheries Co-operative Associations officials for vessel briefing and supervised construction of BSLs with appropriate materials.

CCAMLR was the first regulatory body to prescribe BSLs for use in a demersal fishery (Conservation Measure 29/XVI). New Zealand prescribed BSLs, following CCAMLR specifications, for vessels within its EEZ in 1992 (Duckworth 1995).

There was a high level of BSL use by Japanese vessels in the Australian Fishing Zone prior to it being a regulatory requirement, in 1993 77%, 1994 73%, and 1995 91% (Brothers *et al.* submitted ms). In 1996 more than 99% of observed line sets occurred with BSLs deployed (Brothers *et al.* 1998 However, in fishing controlled by CCAMLR regulations poor levels of compliance persist (CCAMLR 1997). Australian domestic vessels rarely comply, using night-setting as a justification. Half of the few occasions when no BSLs by Japanese vessels were used in 1996 coincided with night-time line setting (Brothers *et al.* 1998).

Inevitably, with high levels of mitigation measure use the opportunities to undertake assessments of a comparative nature regarding efficacy are lost (Brothers *et al* submitted ms). This has also been a consequence of prescribing specific BSL design so, unless an experimental approach is pursued (and this is of questionable value anyway, see earlier reference to this) further improvement to such mitigation measures is unlikely.

In the Falkland Island/Malvinas Outer Fishing Zone BSL regulations also apply (P. Brickle *in litt*.) but it would seem that such regulations do not extend into adjacent waters of South America (C. Moreno *in litt*.). BSL use has been recommended elsewhere (e.g. in South African waters, Barnes *et al.*(1997). Perhaps the recent announcement (late 1997) by the Japanese Fisheries Agency that all Japanese vessels must now use BSLs will encourage similar bird bycatch reduction initiatives by other nations.

Research and development needs.

1. Ongoing assessment of BSL efficacy, particularly with respect to suitability of design for different fisheries.
2. Solicit co-operation from fishing vessel and gear manufacturers to ensure that all vessels are equipped to use BSL most efficiently and effectively: correct pole(s) design and placement, mechanised set and retrieval facility, integrated installation of other equipment to ensure optimum performance eg. position of line shooter and BCM.
3. Assist in promotion of BSL supply outlets.

4.11 BAIT-CASTING MACHINES

Description

Bait-casting machines (BCMs) are used in pelagic longlining where hooks are attached to long branch lines necessitating placed in the water at a distance from the longline to which they are attached to minimise line tangles. It is particularly desirable on larger vessels to put baits in the water outside propeller and hull turbulence. To achieve this each bait is thrown by hand from the port-side stern corner, as far out away from the vessel as possible.

The concept of BCM development was motivated by two potential benefits: reducing both the effort of bait casting and bird catches. For the former this requires i) a cycle time of less than 5 s to match existing bait setting frequency of *c*. 6 s; ii) versatility of casting to either port or starboard; iii) a casting distance of at least 10 m; and iv) integration and operation without disruption to existing line-setting procedures.

Studies from 1988 to 1992 (Brothers 1991) have shown that increased loss of bait to birds and death of birds is aggravated by factors relating to the manual throwing of baits. These are:

1) Baits that are thrown less than five metres from the ship are five times more likely to be taken by birds. More than 20% of baits can be at greater risk of being taken by birds for this reason. Those that are not thrown clear of the ship are more likely to be taken by birds because of turbulent water created by the ship keeping them near the surface of the sea for longer.
2) Because all baits are thrown to the same area in the water, seabirds concentrate their search in this area so few baits escape detection if they are accessible.
3) Whereas all baits should be thrown to the same position, this is not sufficiently accurate (crew ability, weather influence) to ensure that all fall directly under a bird-scaring line.
4) It is necessary that baits are thrown clear of the ship and for efficient manual bait throwing, crew are restricted to throwing off the port side of the ship. Therefore, on occasions when wind strength above 20 knots and/or rough sea conditions onto the ships' port side occur (the side to which baits are thrown), loss to birds increases significantly (30%) as do branch line tangles (Brothers 1993).

With consideration to the above deficiencies of manual throwing the BCM evolved with the following facilities: i) 3.5-4.0 s cycle time, ii) immediate direction reversal switching in order to permit port or starboard side throwing, iii) immediate distance dial facility for varying throw distance according to requirements of weather, BSL placement etc. to maximum distance of 23 m, iv) low arc of throw coupled with gimbal rotation to contend with ship movement in rough conditions and minimise any consequential interference of bird-scaring lines to the fishing line.

Achieving these capabilities necessitated the development of complex (and therefore costly) hydraulic components (by the late Mr M Brooks). However, several hundred units were rapidly produced to fill orders, principally for Japanese and Republic of Korea vessels. This BCM, engineered and distributed by the Australian Company Gyrocast Pty Ltd was soon displaced by machines produced by the Japanese companies Izui Iron Works and Kitagawa Kogyu Co. Ltd. Regrettably these cheaper (and so, more marketable) replacement models were manufactured only with the basic labour saving functions of mechanised throwing. Gone were the additional facilities that really gave the device the potential for huge savings (bait, birds, line tangles). These new machines cannot vary throwing distance or direction and do not integrate well with bird-scaring lines owing to unsatisfactory arc of throw, gimbal facility and no distance variability. This is an example of improvements to fishing efficiency where the only motivation has been short-term economic gain, and the potential for long-term savings and benefits has been lost.

History

The problems associated with how baited hooks are set from pelagic longliners was observed in 1988 (Brothers 1991) and resulted in a commitment to overcome these problems by mechanising the process. This was achieved from 1989 to 1992 by collaboration between Australian engineers and government agencies and the Japanese ship owner Kiichiro Yorozuya, his fishing master Koji Ito (the first to use BSLs and BCMs) and the Japan Tuna Fisheries Cooperative Associations (Brothers 1993).

Distribution of machines on a commercial basis followed almost immediately and by 1996 over 200 machines had been sold to three nations. Redevelopment of this machine commenced in 1996, with a view to improve reliability, cost competitiveness and adaptability to any size of vessel. Performance assessments are currently underway on Korean vessels (Gyrocast Aust. pers. comm.).

The advent of inadequate models has severely curtailed the rapid, earlier rate of uptake of Gyrocast machines. Legal proceedings pertaining to matters of patent ownership etc. (Gyrocast Aust. pers. comm.) are also interfering with BCM sales.

Effectiveness

Data are available regarding the effectiveness of BCMs to reduce bird mortalities but it is necessary to remember that no data exist pertaining to performance assessment of a BCM used to the full extent of its capacity.

BCMs can reduce potential bait loss to birds by half (Brothers 1993). Bait loss without BCMs from a sample observed of 174 873 hooks was 8.5/1000 and with BCMs was 2.7/1000 from a sample of 136 980. One of the biggest uncertainties here is to what extent bait condition can be an influence. This is the only data that attempt to relate BCM use to bait loss rates. Bait loss rates cannot be calculated from data sets which relate BCM use to bird catch rates. A correlation between bird catch rates and bait loss rates may not exist.

Duckworth (1995) and Klaer & Polacheck (1995) found bird catch rate reduction occurs with BCM use but contrary results have also been presented (Brothers *et al.* submitted ms). Evidence of these data being inadequate for meaningful evaluation is apparent and further affirmed by more conflicting results in Brothers *et al.* (1998).

If correctly used, BCM can do nothing but overcome a number of the factors that increase seabird mortality. Measuring its relative contribution to catch rate reduction, although desirable has not been useful to date and might be impractical given the strong influence of other factors that affect catch rates. Also, of all mitigation devices BCM is the only one that, irrespective of regulations will be consistently used owing to its other beneficial attributes. Therefore some level of bird mortality reduction will always be achieved.

Effects on other marine species

Using a BCM keeps more bait on hooks and so of course a potential for increased catch rate exists for target as well as bycatch fish. A deleterious impact is unlikely.

Costs

The original Australian manufactured BCM model cost around $A20 000 whereas the Japanese-made devices were around half this amount. The new generation of Australian BCMs will be similar in cost to these (Gyrocast Aust. pers. comm.).

The cost of the machine is offset by the potential financial benefit from BCM performance in improving fishing efficiency. Estimates of cost saving or profit increase (Brothers 1993) are considerable: up to $A2.6 million annually (depending on how BCM efficiency is utilized) per vessel in the 300-400-tonne range.

Further cost savings and benefits from the BCM are i) machine throwing does not transfer line tension to the baited hook (unlike by manual deployment) which means that less baits are lost in setting and there is no need to use frozen bait; and ii) learning to throw competently is not easy whereas even inexperienced crew can use BCMs with obvious cost-saving potential.

Process of adoption

BCMs may always remain a device considered by fishermen only for its economic attributes, other than to reduce bird catch rates. In view of this and because maximum bird benefit can only come from appropriate use and in combination with other measures (BSL, night setting, appropriate line weighting, consideration to bait condition) regulations are inappropriate.

In the AFZ 3% of observed fishing operations by Japanese vessels occurred with BCM use in 1993 and by 1995 this had risen to 44% (Brothers *et al.* submitted ms) and to 70% in 1996 (Brothers *et al.* 1998). Between one third and one half of Japan's high seas pelagic tuna longliners are now equipped with BCM (Gyrocast Aus pers. comm.), of which less than half of these are thought to be the Gyrocast model.

Research and development needs

1. Promote integrated installation of BCM with other fishing equipment to ensure optimum performance which will benefit fishing efficiency considerably.
2. Discourage manufacture of BCM with inadequate performance.
3. Encourage utilisation of full range of features of BCM.
4. Further attempt to quantify BCM performance for bird catch rate reduction and increased fishing profits.

4.12 FISHING SEASON AND AREA CLOSURES

Where and when fishing occurs may be more important than the actual amount of fishing. For example, to reduce the total fishing effort (de la Mare & Kerry 1994) and have no regard for when and where fishing will take place could conceivably increase bird bycatch. Closing waters south of 30^{o}S would benefit Southern Ocean seabirds considerably, but fishing effort displacement could affect species elsewhere.

For regions where vulnerable species are particularly abundant, as in the New Zealand EEZ (Gaskin *et al.* 1991) there may be clear benefits from area/season closures. The quite small amount of fishing effort here, redirected from such an area of very high bird catch rate potential will contribute comparatively little to total catch increase elsewhere. The issue of bird catch appears to have already caused a significant decrease in fishing effort around New Zealand (Alexander *et al.* 1997).

Croxall & Prince (1996) considered area/season closures in terms of proximity and time of fishing in relation to a species' breeding timetable: concentrated activity of adult birds near their breeding colonies can lead to unacceptably high mortality if fishing occurs at the same time. But, if fishing activity is terminated and it is not known to where that fishing effort will shift, advantages to total catch reduction or species plus age relatedness of catch composition are uncertain.

Trawling is permitted near Australian sub-Antarctic Macquarie Island because to longline fish here would put small populations of several seabird species at greater risk (AFMA 1996). But restricted application of this measure to protect such vulnerably low populations is likely to be inadequate because the birds in question roam farther afield where longlining still occurs. Thus improvement of the longline fishing method is the most appropriate option for overcoming bird catch. The fact that longlining kills seabirds should not be used to give preference to trawling and its generally greater destructive capacity (e.g. Safina 1995). It is therefore important to demonstrate that catching birds on longlines can be avoided. Area/season closures in specific circumstances can arguably be beneficial but are inadequate as a mitigation measure for general use.

The sub-Antarctic Heard and McDonald Islands sector of the Australian Fishing Zone is another example of a fishing ground in which longlining fishing is prohibited (AFMA 1997). There are also those sectors of the Southern Ocean over which CCAMLR rules apply: unless the designated sector has been identified in a nation's notification of intent to fish then fishing is prohibited unless specific conservation measures are adopted.

In addition to the previous descriptions of occasions when area/season closures may be applied the following provides an example of one in which birds and fishermen could benefit from this strategy. In the southeastern Indian Ocean from August to November Whitechinned Petrels occur in low numbers throughout. However, on about the 1 November very large numbers arrive here and are responsible for a substantial reduction in the viability of operations by taking vast quantities of bait from hooks set for Southern Bluefin Tuna (N.P. Brothers unpubl. data). With a minor adjustment to the annual operations routine this problem could be largely avoided. Although such refinements can produce significant benefits it is not so easy to identify when and where opportunities of this nature exist or how stable they are.

4.13 ADDITIONAL MITIGATION MEASURES

There are features of line setting and hauling not yet discussed that can contribute significantly to bird problems. Often minor alterations to gear or technique are sufficient to rectify the trouble. Also described below are the various other methods of mitigation that have been attempted and discarded, or those under development or awaiting development effort.

Line tension prevention

In pelagic fisheries a main line can be set slack (no tension astern) with the aid of a line shooter (Fig. 26) whereas in demersal operations line shooters have yet to be developed. In demersal operations line tension astern keeps baits available to birds for longer and line sinking is delayed. The higher a line departs the ship above the water the worse the problem becomes. This is where setting funnels can be of added benefit.

If weights are being used to sink the line (Spanish twin-line system for example) they must never be left to be pulled off astern by line tension, but pushed off to avoid increased line tension which dislodges bait and also allows birds to be caught more easily. Line tension frequently occurs in the auto line system simply because hooks snag briefly in the auto-baiter or because line loops from hook magazines have become crossed over. Careful attention to gear maintenance and its correct use and training of inexperienced crew is essential. The fishing equipment manufacturing company Mustad, is endeavouring to develop a line shooter for demersal gear which will be a major asset to improving fishing efficiency.

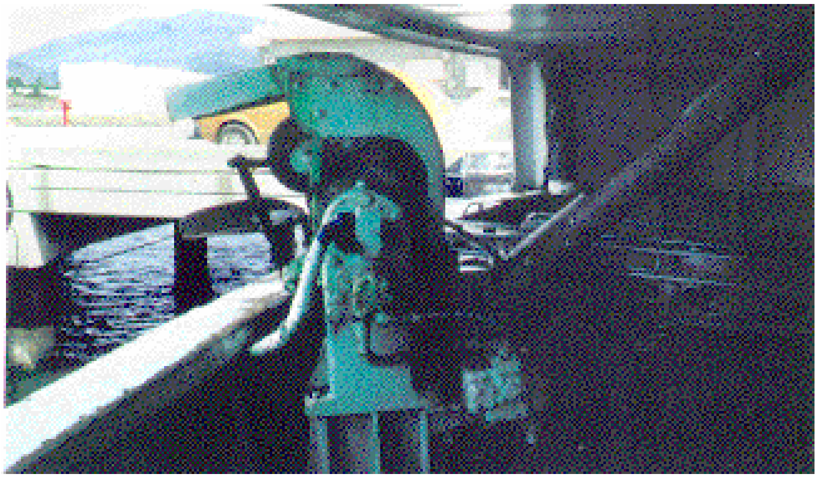

Figure 26. A line shooter for pelagic line setting

Line-hauling problems

Birds can be caught during line hauling, though less frequently than in line setting, and often then come aboard alive, when they can be released. There are a number of reasons why fatalities during hauling occur. In pelagic fisheries long branch lines, after being unclipped from the main line are either pulled aboard manually or with snood pullers or branch line coilers (Fig. 27). Manual recovery is slow and leaves any baited hooks exposed on the surface for birds to eat. If mechanising line recovery is not an option then consideration to branch line length in relation to the distance between the hauling position and the stern of the vessel can help. Provided branch line length is the same or less than this distance baited hooks usually receive adequate protection from the hull of the vessel. A vessel being driven faster than the rate crew can haul in branch lines aggravates the above problem because baited hooks trail astern for longer.

Figure 27. Snood pullers and branch line coilers for pelagic longline fisheries

If an unweighted demersal line breaks, sections can float to the surface and be dragged through concentrations of accompanying birds. In such instances rapid line retrieval should be a priority. A Brickle Curtain can help in thus situation (see Fig. 28).

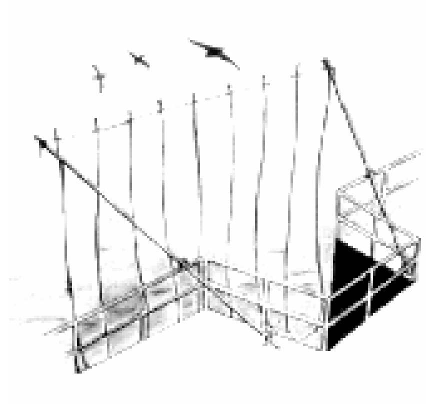

Figure 28. Brickle curtain for demersal longline fisheries

Offal and bycatch discharge and bird-attraction reduction

To reduce numbers of following birds, discarding any item of an edible nature, even cardboard packaging from bait boxes, must be avoided during line setting. Containment of loose bait particles from auto-baiting devices is also necessary. Dumping offal and bycatch during setting can distract birds from baited hooks (Cherel *et al* 1995), but this practice has the disadvantage of attracting birds to the vessel, potentially increasing bird catch, and so has not been generally recommended.

Longliners can produce large quantities of offal, often discharged continuously during hauling. Hauling is often done at a slow speed enabling discharged offal to remain near the discharge outlet usually located immediately adjacent to the line haul position. Large numbers of birds are then attracted to the immediate vicinity of incoming hooks and can get caught (Brothers 1995a, Moreno *et al.* 1996). An exclusion device such as the Brickle Curtain (Fig. 31) reduces the problem.

Ensuring minimum opportunities for birds to obtain food must be the objective. If any material edible or otherwise must be discharged then a once-only event each night, preferably not during hauling or setting, would be the most appropriate strategy. This method should reduce the additional problem of birds ingesting hooks in offal or discard fish. With this system of disposal a Brickle Curtain may be needed as incoming hooks with bait remaining or lost bycatch will still be available and attract some birds. Yet to be demonstrated is whether offal discharge (from the opposite side to where line hauling occurs) during hauling is the better procedure, not only because of the above situation but as a further distraction when whole sections of hook line float after a breakage. Regulations pertaining to offal discharge already apply in some fisheries so resolving such uncertainties is important.

Research and development needs for offal discharge include: i) Evaluation of most appropriate offal discharge practice; and ii) Factory longliner conversion to offal discharge only on opposite side to line haul which is generally forward of amidship on starboard side.

Artificial baits, lures and live bait

Artificial baits may be made of waste fish material still scent-attractive to target species or synthetic baits (lures) that use visual stimulus as an attractant. The former type, made of waste fish and offal (e.g. Anon. 1997f), has not yet been assessed for its affect on seabird catch rates, although it is being used commercially in a number of demersal longline fisheries. Seabirds rely heavily upon vision to locate food sources, so dyeing artificial bait to make it less visible should be tested. Also, the potential to manipulate the buoyancy of artificial bait in order to accelerate sink rates should be explored.

Synthetic baits or lures are commonly used in pelagic fisheries either on their own at hooks or combined with a baited hook. Generally they are crude imitations of natural bait items such as fish or squid. Considerable potential exists to develop lures that may be more effective and less costly than natural baits. Seabirds are generally highly discerning of food items and synthetic lures would therefore pose little threat. As yet there are no records of seabirds having been caught on synthetic lures in longline fisheries (N.P. Brothers unpubl. data) although lures that are trolled do attract and catch birds.

Although no assessments have been undertaken of live bait anecdotal reports by Australian fishers suggest that seabird bycatch does not occur because such bait descends rapidly by active swimming.

Research and development needs are i) establish whether artificial bait in demersal longlining affects bird catch rate; if more determine whether processes such as dyeing may reduce bird catch; and ii) assess the feasibility of lures.

Hook design

In demersal longlining hook shape and diameter may affect bird catch rate (Brothers 1995, Moreno *et al.* 1996). Smaller hooks may more easily catch smaller species (Brothers & Foster in press). Hook size (weight) will influence bait sink rate (Brothers *et al.* 1995). The development of hooks with disarming mechanisms that would delay the catching ability to a predetermined time or depth is under investigation in Australia (Munro Engineers and Grandson Pty Ltd).

Research and development needs: i) Completion of research into hooks with disarming mechanisms; Further understanding of the roles that hook size, shape and particularly weight play in catching seabirds.

Water cannons

The use of water from a vessel as a means of concealing baited hooks may reduce bait loss and incidental catch of birds, providing baits do not remain accessible too far astern. In 1997 the Japan Tuna Fisheries Co-operative Assoiciations tested a high-pressure fire hose (Fig. 29) that directed high-pressure water above baited hooks. Non-quantified observations suggested a reduction in seabird interactions, although the distance astern to which the water reached was considered inadequate. The cannon was switched off because cold, wind-driven water adversely affected the crew (S. Lake, Australian Fisheries Management Authority observer pers. comm).

Acoustic deterrents

A sudden loud noise (e.g. firearm discharge or hitting steel hull) may cause nearby seabirds to fly away, a technique erratically used by fishers. to frighten birds. However, loud noises frighten seabirds only briefly and at close range. Also, the more often the frightening sound is produced, the less effect it has due to rapid habituation, as with gas guns in agricultural situations. Other commercially available acoustic bird-scaring devices emit high frequency and loud noises or distress calls. These may be effective if used sparingly to avoid habituation.

In 1996 albatrosses in a breeding colony were subjected to high-frequency and loud noise as well as distress calls with no detectable response (N.P. Brothers unpubl. data). Tests from a vessel to which a variety of seabird species was attracted by fish offal discharge showed most birds ignored sounds, although occasionally the sudden commencement of sound emission caused a bird to fly off a short distance. Further investigation of acoustics as an effective mitigation measure was then regarded as futile. Despite the lack of response generally the frequency of bait taking in fisheries would necessitate such regular sound emissions that habituation would be rapid, as would annoyance to the crew.

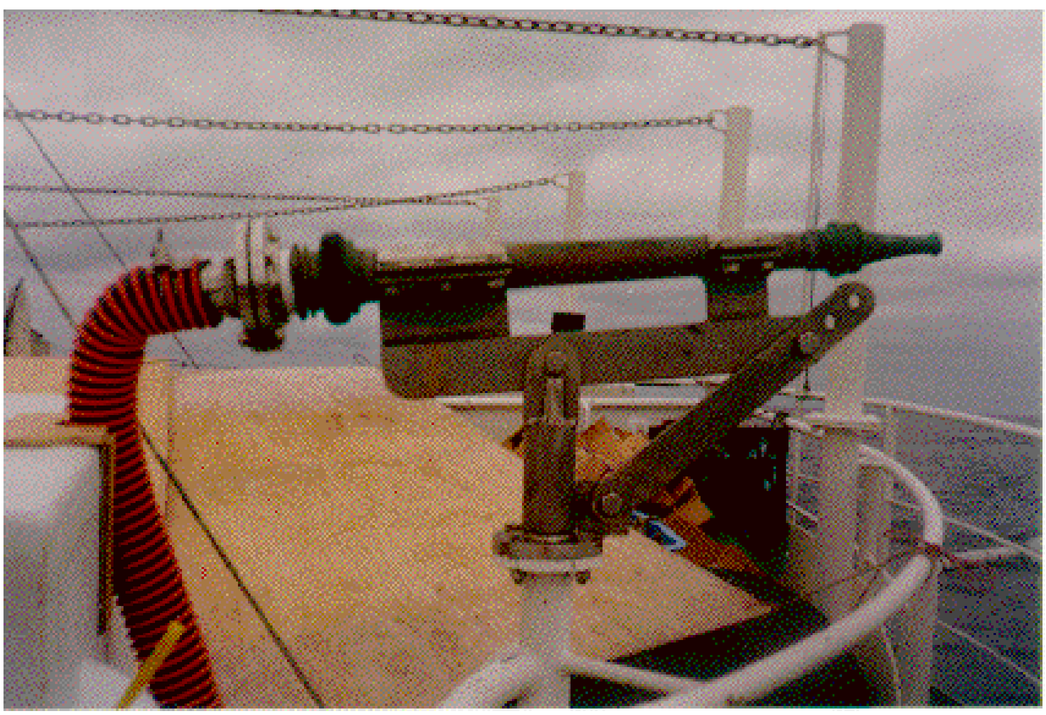

Figure 29. Experimental water cannon on a pelagic longliner (courtesy S. Lake).

Magnetic deterrents

Several commercially available bird scaring devices produce a magnetic field, claimed to interfere with receptors that birds have for detecting such forces. A wind-driven propeller with attached magnets tested by the Japan Tuna Fisheries Co-operative Associations on pelagic longliners in 1993/94 had no significant effect on seabird catch (Brothers *et al.* submitted ms). The same device in an albatross breeding colony was either ignored or pecked inquisitively (N.P. Brothers, JFA unpubl data). A literature search failed to indicate that a device of this nature could be effective as a bird scarer. Magentic deterrents are unlikely to offer protection to the 100 m or more astern required with present line-setting methods. More powerful super conducting or electromagnetic devices have not be assessed.

Smoke deterrents

In favourable conditions (line setting against the wind) smoke emitted from refuse disposal incinerators has been reported to have a discouraging effect on seabirds astern (T. Arimoto *in litt*.). Inability to control wind direction makes this most unlikely to be of value as a deterrent.

Education

Fishers need to understand why catching birds should be avoided. in the past there has been insufficient financial incentive alone but with additional incentives now emerging the process of resolution is perhaps unavoidably reliant on cooperative strategies. This is why a process of information gathering about fishing and bird interactions evolved for fishers who have the incentive and knowledge to solve the problem - for their own sake as well as for the birds. The first educative booklet was published in Japanese with English and Indonesian summaries (Brothers 1994a, Fig. 30), 2000 of which were distributed by the Japan Tuna Fisheries Co-operative Associations to all Japan's vessels and their owners. This booklet was the basis of an English version (Brothers 1995b), 3000 of which were distributed by the Australian Fisheries Management Authority to all vessels and fisheries officers in Australia with further copies provided for distribution in New Zealand and elsewhere upon request. This version has since been translated and distributed to Vietnamese and Korean longline operators (E. Flint *in litt*.). It also formed the basis for a CCAMLR booklet (CCAMLR 1996) distributed to CCAMLR member nations in English, French, Russian and Spanish versions.

A more comprehensive edition of Brothers (1995b) for all longline methods was produced in combined English and Spanish (Brothers 1996). Of the 4500 distributed mostly to fishers worldwide, 3000 of these were ordered by the North Pacific Longline Association. An Afrikaans translation, as yet unpublished, has been made for use in South Africa’s domestic longline fisheries (P.G. Ryan pers. comm.). Other educational products include articles in fishing and environmental magazines and pamphlets (e.g. Anon. 1991, Anon. 1997e, Duckworth & Wells 1995) and videos produced for the North Pacific demersal longline fisheries (T. Smith *in litt.*) and for the Spanish twin-line system by N.P. Brothers and distributed throughout South America.

Figure 30. Books for fishermen describing mitigation methods and giving information about seabirds

For many years the Japan Tuna Fisheries Co-operative Associations have disseminated information directly to Japanese longline vessels, placing this fleet well ahead of most in awareness of bird problems and the solutions available. Similarly active are international and several national fisheries and nature conservation bodies.

A balanced attitude is desirable. Too much pressure where concerted efforts are already being made by fishers is potentially destructive to the adoption of mitigation measures Fisheries and nature conservation managers should be aware of appropriate mitigation regulations.

Research and development needs

1. Maintain and improve education/information dissemination and extend to all longline fishing nations.
2. Preparation of appropriate materials to incorporate in training courses for fishers.
3. Preparation of appropriate materials for distribution to equipment and vessel manufacturers in order to stimulate development of new mitigation measures.

Stock enhancement

The term stock assessment is taken to mean the managing or manipulation of existing seabird populations with the intention of their increasing abundance and or distribution. If killing seabirds on hooks threatened populations then achieving population increases could conceivably be a mitigation measure (one that could also absolve fishers from having to use alternative methods of mitigation). Perhaps the best relevant example of such a process is that to assist recovery of Short-tailed albatrosses (Hasegawa in Gales 1993). In this instance, the species natural rate of recovery was assisted by nesting habitat improvement and relocation to more secure habitat using decoy birds. However. the fixed life-strategies (e.g. high fidelity to breeding site, fixed clutch size, etc.) of most seabird species affected suggests that success potential is likely to be very low

4.14 PRESCRIBING MITIGATION MEASURES

This is not an easy task particularly because the following points must be considered.

i) suitability and effectiveness of existing devices has been poorly demonstrated.
ii) uncertainty of options given that a number of these have yet to be developed.
iii) effectiveness of an option is closely related to the degree of need for monitoring to ensure that it is being used.

To complicate matters further there is the prospect of combining use of certain measures to improve overall mitigation performance. Take for example just the following six measures, bait-scaring lines, night setting, line weighting, bait quality, Bait-casting machines and underwater setting. There are 30 combinations in which these measures can be applied with varying consequence to bird catch rate reduction.

Further, the degree of benefit can also vary depending upon the longline method. This is illustrated in Table 9, assuming that underwater setting alone would avoid bird mortality totally and that all measures or combinations of measures are to be consistently and correctly used.

Apart from the preceding considerations to mitigation measure selection there is also the need to include suitability criteria. These can be safety aspects, set up and operating costs, impact on catch rates (other than bird), all of which can determine whether a measure will be used irrespective of its bird-catch rate reduction performance - the unavoidable problem of compliance.

4.15 IMPEDIMENTS TO MITIGATION

Practical complications have already been covered in this report but there can be other impediments to progress. Internationally recognised experts were asked what impediments they saw to mitigation measure progress. Their answers are summarised below. Assessing such issues can be important for determining an effective mitigation process. Opinions were sought from 11 persons from seven nations and they identified five key problem areas.

Lack of education was the most frequently mentioned deficiency, followed by issues relating to compliance. Lack of general awareness of the issue, excessive pressure on fishermen to perform, and inadequate mitigation measure development were all considered important.

Table 10. An example of the complexities in application of mitigation measures and how effectiveness can vary with longline method (catch reduction figures have been estimated)

Mitigation Measures for Line Setting	Seabird Catch Rate Reduction Estimate (%)	
	Longline Method	
	Demersal	Pelagic
Underwater setting	100	100
Night setting	90	80
Night setting + BSL	95	90
Night setting + line weight	100	90
Night setting + bait quality	90	85
Night setting + BCM	N/A	85
Night setting + BSL + line weight	100	95
Night setting + BSL + bait quality	95	80
Night setting + BSL + BCM	N/A	95
Night setting + line weight + bait quality	100	95
Night setting + line weight + BCM	N/A	95
Night setting + bait quality + BCM	N/A	95
Night setting + BSL + line weight + bait quality	100	95
Night setting + BSL + line weight + BCM	N/A	95
Night setting + BSL + line weight + bait quality + BCM	N/A	98
BSL	80	70
BSL + line weight	90	85
BSL + bait quality	80	80
BSL + BCM	N/A	75
BSL + line weight + bait quality	90	90
BSL + line weight + BCM	N/A	85
BSL + BCM + bait quality	N/A	80
BSL + line weight + bait quality + BCM	N/A	90
Line weight	80	60
Line weight + Bait quality	80	75
Line weight + BCM	N/A	70
Line weight + Bait quality + BCM	N/A	80
BCM	N/A	40
BCM + bait quality	N/A	50
Bait quality	0	20

Compliance with the use of mitigation measures

Already discussed is the probability that an effective mitigation measure is only one that will be used without the need for monitoring or regulations. So far, it would seem measures of this nature are either yet to evolve, be widely available or be widely used. Inevitably regulatory processes have therefore been adopted in an attempt to ensure compliance and to date apply to measures that fishermen cannot be bothered to use or have preconceived ideas about economic or logistic consequences. Regulations pertaining to bird mortality reduction now exist for the longline fisheries of a number of nations and also apply to vessels of one nation (Japan) irrespective of whose regulatory influence the waters being fished are under. There is also one convention (CCAMLR) to which many nations are signatories where regulations apply. The nature of these regulations are summarised in Table 11.

Table 11. Regulations in effect for reducing seabird catch by longline fisheries

Country or Convention	Year of adoption	Fishery type	Area of application	Mitigation measure required
Australia	1995	Pelagic (tuna)	AFZ south of 30^{o}S	BSL
Japan	1997	Pelagic	High seas	BSL
New Zealand	1993	Pelagic	EEZ	BSL
South Africa	199?	Demersal	Sub-Antarctic EEZ	As for CCAMLR
South Africa	1998	Pelagic	EEZ	BSL, offal discharge
United Kingdom	?	Demersal	Outer fishing zone of FalklandIslands/ Malvinas	BSL, (weighted lines, night setting if instructed specifically)
U.S.A. U.S.A.	1997 -	Demersal Pelagic	West Pacific EEZ Hawaii EEZ (planned)	BSL, towing objects, weighted lines, offal discharge, underwater setting, night setting
CCAMLR	1992	Demersal	CCAMLR region	BSL, weighted lines, offal discharge, night setting

No other nations are known to have applied regulations and with the exception of Japanese vessels all other vessels to which regulations apply need not comply if fishing beyond their EEZs. New Zealand is apparently investigating this deficiency for application to its own vessels. The status (in a regulatory sense) of instructions to Republic of Korea vessels is uncertain.

4.16 THE FUTURE

Alexander *et al* (1997) provide a list of international treaties, conventions, agreements and international multilateral agencies with a relevant management role in this issue. To add to this list are processes that have occurred or have been planned to address the problem such as a Workshop on the Incidental Mortality of Albatrosses in Longline Fisheries (a by-product of the First International Conference on the Biology and Conservation of Albatrosses, 1995), a London workshop on environmental science, comprehensive and consistency in global decision on ocean issues (Dunn 1995), the establishment of the International Southern Oceans Longline Fisheries Information Clearing House (1997), and the FAO consultation for developing draft mitigation guidelines and a Plan of Action (FAO 1998).

Other activities underway that involve development or assessment work related to seabird mortality reduction include:

NMFS, USFWS & IPHC	research plan to test effectiveness of the required mitigation measures.
WPRFMC	seabird workshop and research planning meeting and recent funding to conduct studies on effectiveness of seabird avoidance measures (1998)
IMR	project to develop an effective, cheap and easy to use device and demonstrate efficacy (1998)
EA	TAP process to formulate mitigation measures and a process of efficacy assessment and further developments (Environment Australia 1998).

NMFS	National Marine Fisheries Service (USA)
USFWS	U.S. Fish & Wildlife Service
IPHC	International Pacific Halibut Commission
WPRFMC	Western Pacific Regional Fisheries Management Council (USA)
IMR	Institute of Marine Research (Norway)
EA	Environmental Australia

There are other similar processes underway or planned, many of which have been specified within this report's separate discussions on each different mitigation measure.

The fishing industry often finds it difficult to see any benefit from most of these processes because it bears the brunt of criticism and condemnation irrespective of individual efforts made toward mitigation. This in turn can result in a reluctance to embrace the need for mitigation, but the fishing industry can benefit from the injection of ideas and developments that result from an increased awareness of the issue of seabird incidental catch from longlining.

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