IOTC-2005- WPBy-06

Incidental mortality of seabirds, turtles and sharks: A review of data collected east of 20 degrees by South African observers

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Contents

1. Introduction

1.1 Background to IOTC

The Indian Ocean Tuna Commision (IOTC) came into force in 1996 and operates both within country Exclusive Economic Zones (EEZ) and on the highs seas east of 20 degrees latitude (fig 1). It is responsible for the management of tuna and billfish stocks in the Indian Ocean. The main fishing gear used in the commission area are Purse Seine (c. 38% catch), longline (25% catch) and artisanal fisheries (gillnet, pole and line, troll) (IOTC 2004). IOTC has 23 members and 2 cooperating non-members of which South Africa is one. In 2002 the IOTC resolved to establish a Working Group on Bycatch. Within this, IOTC resolved to implement a regional IPOA-sharks. At the 9th Meeting of Parties one resolution (appendix 1) concerning the conservation of sharks caught in association with fisheries managed by IOTC and two recommendations on incidental mortality of seabirds (appendix 2) and on sea turtles (appendix 3) were adopted.

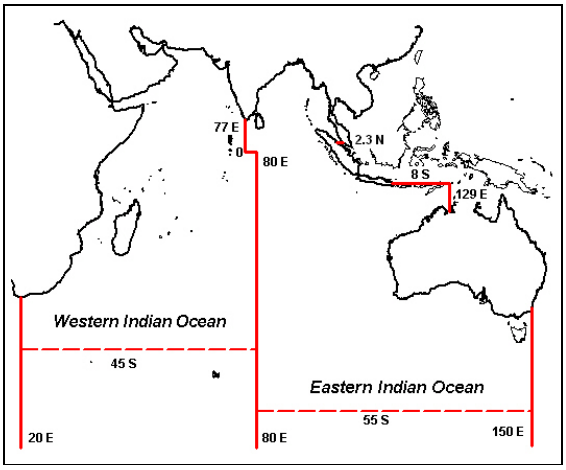

Figure 1. IOTC convention area

1.2 History of the pelagic longline fishery in South Africa

The earliest record of a South African domestic pelagic longline fishery date back to the early 1960s. This fishery predominantly targeted Albacore *Thunnus alalunga,* Southern Bluefin *T. maccoyii* and Bigeye *T. obesus* tunas (Cooper & Ryan 2003). Effort waned in the domestic fishery in the mid 1960s, as interest shifted to more lucrative fisheries. Thereafter pelagic fishing effort was largely conducted by Japanese and Taiwanese vessels as part of a bilateral agreement. Their fishing effort accounted for 96% of the *c.* 12 million hooks set annually within the South African EEZ during 1998-2000 (Ryan & Boix-Hinzen 1998, Ryan *et al.* 2002). In 1995 a permit was issued to conduct a joint venture between a South African and Japanese vessel. This joint venture showed that tuna and swordfish could be profitably exploited in South African waters and consequently the directorate Marine and Coastal Management issued 30 experimental permits in 1997.

All foreign licences were revoked in 2002. This has resulted in a smaller and domestic fishery operating in South Africa's Exclusive Economic Zone (EEZ). The domestic fishery was further developed in 2004 when 50 commercial fishing rights were made available for allocation. Twenty six rights (11 Korean, 2 Philippine and 4 South African flagged vessels; remaining permits under ship building contracts) were allocated to vessels fishing for tuna and 17 for those fishing for swordfish (15 South African, 1 Belize and 1 Australian flagged vessel) in March 2005.

1.3 Affected bycatch species

The species most severely affected by incidental mortality in longline fishing operations share a common life-history strategy and include seabirds, turtles, sharks and rays and sunfish. They are all *k*-selected species, meaning that are generally longlived (have low natural adult mortality), breed slowly and/or have low recruitment into the breeding population. This life history strategy makes these species especially vulnerable to over-exploitation at even relatively low mortality rates. Increases of even one or two percent in adult mortality due to longline fishing can lead to substantial population decreases (Weimerskirch *et al*. 1997). These factors combined with the small global populations of some cases make these species extremely vulnerable to even small numbers of mortalities to adults due to longline fishing.

The fact that bycatch events are rare complicates perceptions regarding the need for conservation. For example, for every seabird taken, hundreds of target fish are caught and in many cases the majority of sets are made with no capture of seabirds. Furthermore, often hundreds of seabirds feeding on discards typically surround the vessel creating the impression to individual fishers that seabird bycatch is insignificant. However, small numbers caught by individual vessels add up when they are considered for the entire fleet or the region and are resulting in population declines.

Seabirds

The Indian Ocean is an important foraging area for 15 species of albatross, 13 of which are threatened with extinction (according to IUCN criteria; BirdLife International 2004a), mostly due the effects of longline fishing (Table 1). The southwest Indian Ocean is important for albatross conservation, particularly for the Critically Endangered Amsterdam albatross and the Endangered Indian Yellow-nosed.

Table 1: Albatrosses found within IOTC convention area (BirdLife International 2004b)

Species	Threat category	% distribution
Amsterdam *Diomedea amseterdamensis*	Critically Endangered	100
Antipodean *Diomedea antipodensis*	Vulnerable	2
Black-browed *Thalassarche melanophrys*	Endangered	21
Buller's *Thalassarche bulleri*	Vulnerable	2
Grey-headed *Thalassarche chrysostoma*	Vulnerable	16
Indian Yellow-nosed *Thalassarche carteri*	Endangered	78
Light-mantled *Phoebetria palpebrata*	Near Threatened	17
Northern Royal *Diomedea sanfordi*	Endangered	29
Shy *Thalassarche cauta*	Near Threatened	41
Sooty *Phoebetria fusca*	Endangered	49
Southern Royal *Diomedea epomophora*	Vulnerable	29
Tristan *Diomedea dabbenena*	Endangered	4
Wandering *Diomedea exulans*	Vulnerable	24
Campbell *Thalassarche impavida*	Vulnerable	13
Salvins *Thalassarche salivini*	Vulnerable	2

Turtles

Five species of turtles occur within the southern western Indian Ocean (Loggerhead *Caretta caretta*, Leatherback *Dermochelys coriacea*, Green *Chelonia mydas,* Hawksbill *Eretmochelys imbricate,* Olive Ridley *Lepidochelys olivacea*) (Payne *et al.* 1995), all of which are Endangered (IUCN redlist). Over time there has been some fluctuation in population numbers due to changes in water temperature, predators and anthropomorphic origin (Payne *et al.* 1995), but the extent to which incidental mortality by longline fisheries contributes to these trends is at present largely unknown for this region.

Sharks

The oceanic and inshore waters surrounding Southern Africa are frequented by 36 species of sharks that are classified as threatened, near-threatened or data-deficient by the IUCN (IUCN redlist). Nineteen of these species are threatened by either directed fishing operations or due to bycatch on other fisheries, eight of which longline bycatch is a known threat. These include the Thresher Shark *Alopias vulpinus*, Great Hammerhead *S. mokarran*, Scalloped Hammerhead *S. lewini*, Smooth Hammerhead *S. zygaena*, Shortfin Mako *Isurus oxyrinchus*, Blue Shark *Prionace glauca*, Porbeagle Shark *Lamna nasus* and Crocodile Shark *Pseudocarcharias kamoharai*.

2. Data collection and analysis

Data were collected by sea-fisheries observers on board South African flagged pelagic longline vessels from 2000 to 2003. These vessels carried rights to fish within South Africa's EEZ as well as on the high seas. Data were also collected from foreign flagged vessels operating under South African licence (two trips in 1999, one in 2004 and seven in 2005, Table 3). These data were made available by Marine and Coastal Management, Department of Environmental Affairs and Tourism.

Identification of species was made by observers at sea with some verification on return to port by the observer agency (Chris Heineken pers com). Only experienced observers were placed on pelagic longline vessels and therefore we have some confidence in species identification. However, Ryan *et al.* (2002) report misidentification by observers.

Catch rates were calculated by dividing fishing effort into one degree by one degree grid squares and into six bio-geographical regions (Fig. 2) modelled on those used in the South African National Biodiversity Assessment (NBA) (Lombard 2004). Levels of bycatch are reported as catch rates (numbers caught per 1000 hooks), which were calculated using the following formulae.

$$\hat{C}_s = (C_{sr} * E_{cr}/E_{or}) + (C_{sr} * E_{cr}/E_{or}) + (C_{sr} * E_{cr}/E_{or})$$

Where $\hat{C}$ = Estimated total bycatch of a species, s.
C_{sr} = Observed bycatch of a species, s within region, r.
E_{cr} = Number of hooks deployed within region, r.
E_{or} = Number of hooks observed within region, r.
s = Any species or group of species
r = Bioregion or one degree grid square

Seasons were defined as follows: summer = December - February, autumn = March -May, winter = June - August and spring = September - November. The term "released" refers to when an animal returned to the ocean alive whereas "discarded" refers to when an animal was dead on being returned to the ocean.

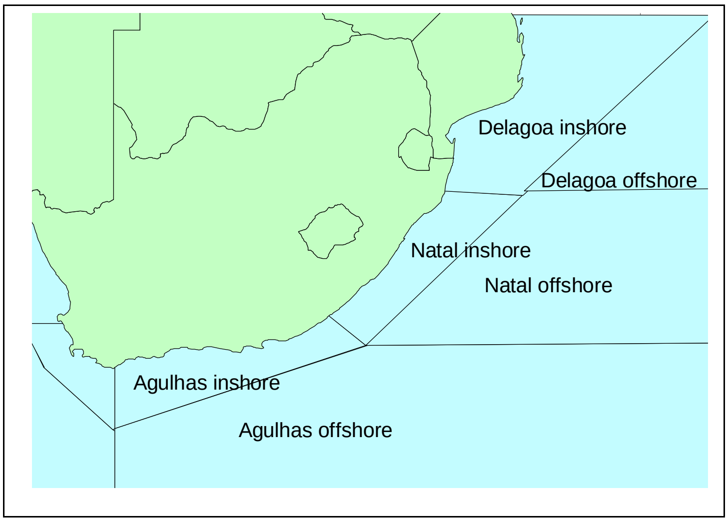

Figure 2: The bio-geographical regions used to classify data spatially in this study

3. Description of gear used

A differentiation is made between foreign and domestic vessels in this report based on the fact that two distinct pelagic or surface longline gear configurations are used in South African waters based on the target species (Fig 3). To target swordfish, hooks are generally set shallow, seldom deeper than 40 m (Fig 4.), by using short buoylines and branchlines and no line setter. Lightsticks are used and gear is set predominantly at night (Fig. 5). This gear configuration generally characterizes the South African domestic fleet (Fig. 3). Those vessels targeting tuna set hooks deep (often deeper than 200 m) by using a line setter and long buoylines and branchlines. Lightsticks are seldom used. Gear is frequently set in the early hours of the morning (Fig. 5). This gear configuration is generally employed by the Japanese, Taiwanese and Korean fleets operating in South African waters (Fig. 3).

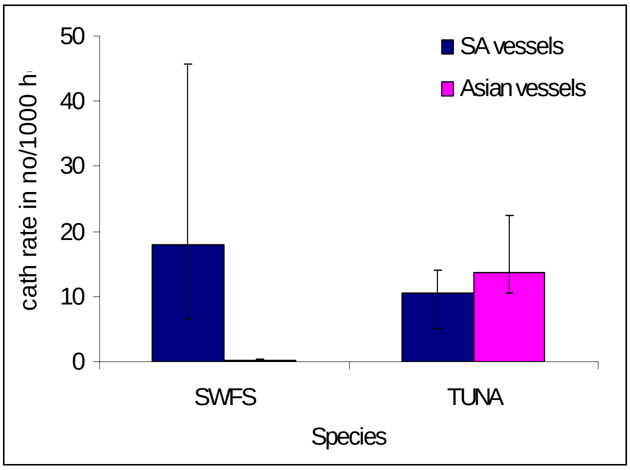

Figure 3. Species targeted by vessel flag state

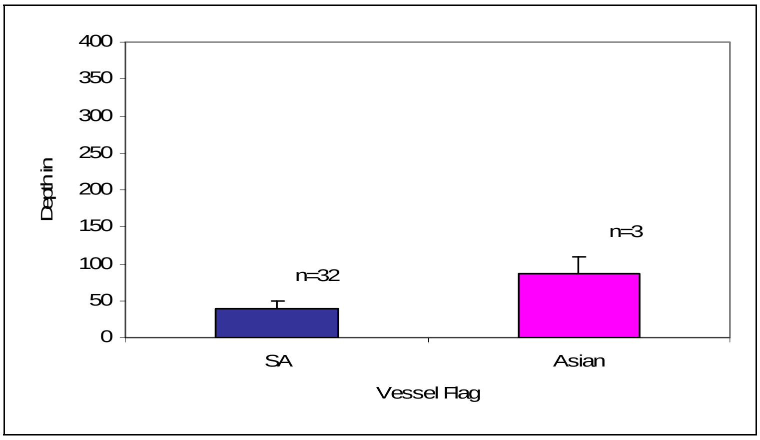

Figure 4. Setting depth per flag state

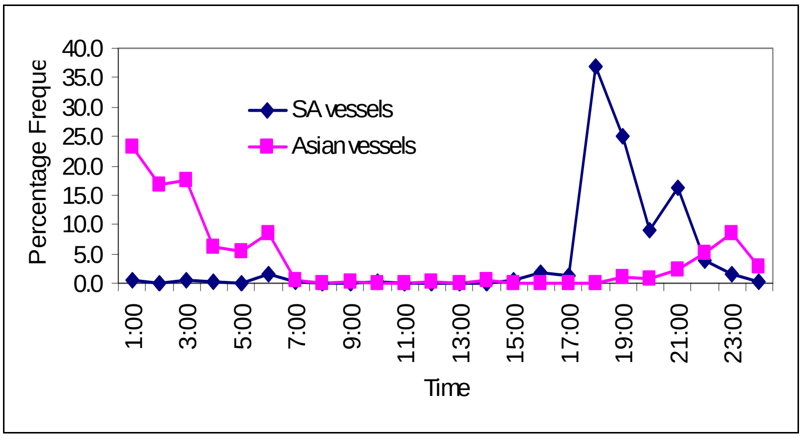

Figure 5. Time of set per flag state

4. Effort

The South African longline fleet operate partially within the IOTC convention area, most notably in the south western Indian Ocean sub-region between 20 and 45 degrees east and 23 and 40 degrees south (Fig. 6). A total of 4.1 million hooks were set between 2000 and 2003 by domestic pelagic longliners within the IOTC convention area. Bycatch (seabirds, turtles and sharks) data were collected from 9% of hooks set (Table 2). Less than 1% observer coverage was achieved on the foreign flagged vessels however seabird bycatch data was collected from 10 trips (1999-2005) which set approximately 350 000 hooks (Table 3).

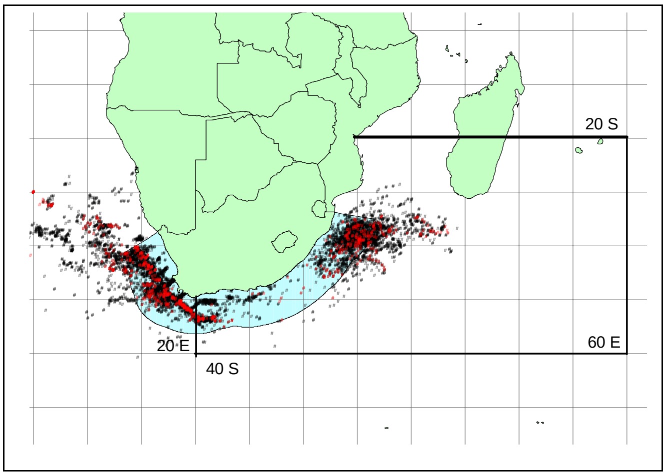

Figure 6: Spatial distribution of fishing effort by South African fleet (Red and black dots represent observed and un-observed sets, respectively).

Table 2: Hooks set per bioregion with percentage observed in parentheses (domestic vessels).

BIOREGION	2000	2001	2002	2003	Total
Agulhas inshore	527989 (5%)	59289 (13%)	61941 (17%)	144325 (1%)	793544 (6%)
Agulhas offshore	76156 (20%)	37488 (46%)	38831 (7%)	106842 (1%)	259317 (14%)
Natal inshore	17652 (0%)	29754 (52%)	360915 (6%)	287166 (5%)	695487 (7%)
Natal offshore	0 (0%)	236559 (18%)	833633 (14%)	868081 6%)	1938273 (11%)
Delagoa inshore	0 (0%)	0 (0%)	67347 (0%)	171061 (13%)	238408 (9%)
Delagoa offshore	0 (0%)	3319 (0%)	41564 (14%)	174003 (8%)	218886 (9%)
Total	621797 (7%)	366409 (23%)	1.4 million (11%)	1.7 million (6%)	4.1 million (9%)

Table 3: Seabird bycatch data collected onboard foreign vessels

Year	No. of trips	Hooks deployed	No. of birds killed	Catch rate
1999	2	79101	164	2.07
2000	none	-	-	-
2001	none	-	-	-
2002	none	-	-	-
2003	none	-	-	-
2004	1	95220	26	0.27
2005	7	168150	90	0.54
Total/mean	**10**	**342471**	**280**	**0.82**

5. Bycatch

5.1 Seabirds

White-chinned petrels were the most commonly caught species, followed by Black-browed, Shy and Indian Yellow-nosed albatrosses. The catch rate averaged 0.2 birds/1000 hooks for the domestic fleet (Table 3) and ranged between 0 and 4 birds/1000 hooks per one degree grid square (Fig 7). Foreign vessels caught on average 0.8 bird/1000 hooks (Table 3). Catch rates ranged between 0.2 and 5.4 birds/1000 hooks (Fig 8).

Catch rates differed between areas (Table 4) and between seasons (albatrosses: $X^2 = 29$, Black-browed Albatrosses: $X^2 = 11.7$, $p<0.001$, Shy Albatrosses: $X^2 = 10.9$, $p<0.0025$, petrels: $X^2 = 27.5$ White-chinned Petresl: $X^2 = 27.8$, $p<0.001$, df = 3). Catch rates were highest in winter for Black-browed Albatrosses, in autumn for Shy Albatrosses and in spring for White-chinned Petrels. No seasonal trend was apparent for Indian Yellow-nosed Albatrosses. The birds caught most commonly in summer were mainly unidentified albatrosses and great-winged petrels (most likely mis-identified White-chinned Petrels).

Table 4. Catch rates of birds caught per bioregion (domestic vessels)

BIOREGION	2000	2001	2002	2003	Total
Agulhas inshore	0.42 (222)	0.13 (8)	0.38 (24)	0 (0)	0.32 (253)
Agulhas offshore	0.13 (10)	0.17 (6)	0 (0)	0 (0)	0.06 (16)
Natal inshore	-	0 (0)	0.90 (325)	0 (0)	0.47 (325)
Natal offshore	0.02 (0)	0.02 (5)	0 (0)	0.04 (35)	0.02 (39)
Delagoa inshore	-	-	0 (0)	0 (0)	0 (0)
Delagoa offshore	-	-	-	0 (0)	0 (0)
Average catch rate	0.2	0.1	0.3	0.01	0.2

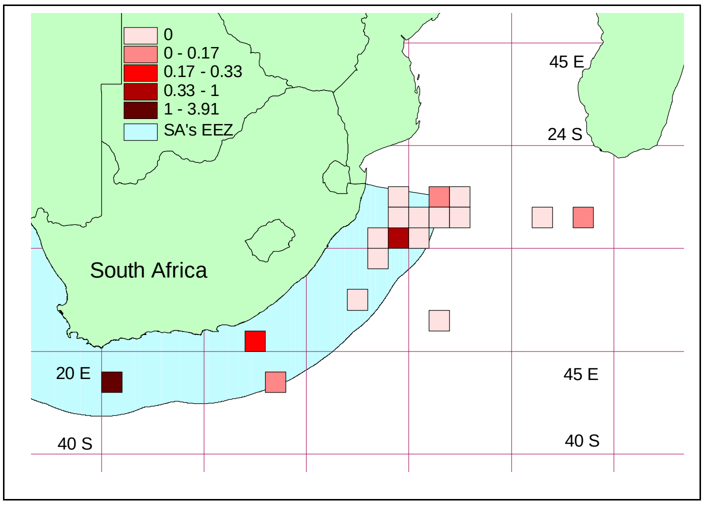

Figure 7. Catch rates of seabirds by domestic vessels per one degree grid square (2000-2003)

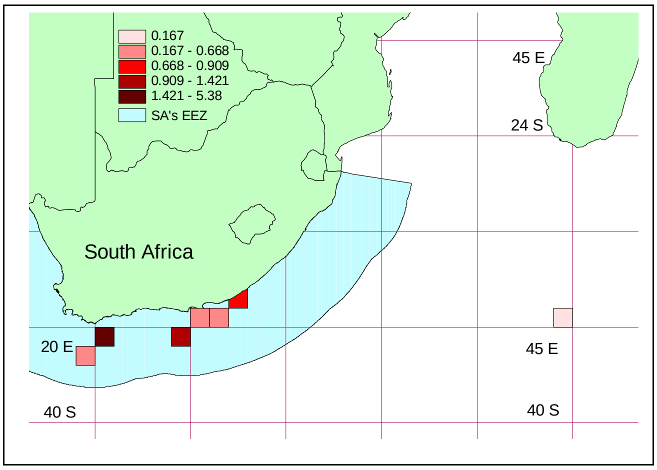

Fig 8: Catch rates of seabirds by foreign flagged vessels by one degree grid square (1999-2005)

Catch rates are higher than the FAO target of 0.05 birds caught per 1000 hooks. This bycatch can and should be mitigated by the following measures: Lines should be set at night, be appropriately weighted in order to maximize their sink rate, a bird-scaring line should be flown during setting and the discarding of offal should take place on the opposite side to hauling. Many of these are permit conditions of this fishery. Each mitigation measure is discussed:

1. Setting lines at night

Albatrosses mainly feed during the day. Therefore by setting lines between the time of nautical dusk and nautical dawn, the danger of catching these birds is greatly reduced. However, the smaller petrels e.g. White-chinned Petrel may feed at night and therefore are not fully protected. Vessels targeting swordfish, which is typical of the South African domestic fleet, usually set their lines in the early hours of the night, compared to those targeting tuna, typical of the foreign flagged vessels, which usually set their lines at dawn. This may account for the difference in bycatch rates reported in this study.

2. Streaming a "*tori*" or "bird-scaring" line

A *tori* or bird-scaring line consists of a line with a number of streamers attached to it. This line is towed from the stern of the vessel while the baited lines are being set. The streamers are designed to cover the point where the baits enter the water and distract foraging birds from taking the baited hooks. The system works well against surface-feeding birds. However, a major limiting factor of this system is that diving birds can still get down to the bait outside of the effective area of the streamers. This method can reduce bycatch rates by up to 80 %, however its efficacy depends on a number of factors.

- *Maximising aerial coverage:* The key to an effective *bird-scaring* line is maximising the portion of the line which is in the air. The best way to achieve this is to make the point of attachment on the vessel as high as possible. 7 m above the water surface should be considered a minimum. On small vessels where a high attachment point is not accessible, an outrigger pole can be mounted to provide this height. The aerial coverage is also improved by attaching an item e.g. a buoy which creates drag to lift the line out of the water.

- *The importance of streamers:* Streamers can be made from plastic strapping or pvc tubing. They should be a bright colour, preferably red. Streamers should be placed every 5 m along the entire aerial section of the line. The erratic movement of the streamers increases it efficacy. Attaching light sticks to streamers may increase the efficacy of the bird-scaring line when setting at night.
- *Adjusting the bird-scaring line:* Once a *bird-scaring* line is operating at its full height a "lazy line" attached and tied off at a convenient point on the stern allows the *bird-scaring* line to be quickly retrieved. This is particularly important if the line gets snagged as it can be quickly pulled down, unclipped and clipped onto the backbone, allowing the vessel to continue setting. The *bird-scaring* line can then be retrieved during hauling. The lazy line also allows the *bird-scaring* line to be adjusted according to wind conditions. To be effective a *bird-scaring* line should be over the point where gear enters the water. By tying the "lazy line" on the windward side of the vessel, it can be effectively used to adjust the *bird-scaring* line so that it is positioned directly over the gear.
- *Ease of use:* It is important that the *bird-scaring* line is easy to use. To save space it can be stored in a plastic hose reel or in a fish bin. It is important that the line does not foul the gear being set. To prevent this from happening floats and mid-buoys should be thrown downwind so that they do not float back onto the *bird-scaring* line. Altering the course slightly when radio bouys are thrown into the water may also prevent them from becoming snagged.

3. Line weighting (and reducing setting speeds)

Albatrosses are relatively shallow divers (0.3-12.4 m) (Prince *et al.* 1994) although some petrels can dive considerably deeper than this depth e.g. Sooty Shearwater *Puffinus griseus* can dive to at least 67 m (Weimerskirch & Sagar 1996). By minimizing the time hooks are within the reach of the birds, seabird bycatch can be reduced. Various "line weighting" regimes have been investigated. CCAMLR regulations state that vessels operating in the Convention Area must achieve a line sink rate of at least 0.3 m/s. Time-depth recorders deployed on pelagic vessels in South African waters suggest that two 60 g swivels (total 120 g) on the branchline 3.6 m from the baited hook set at a speed of 8 knots will result in a sink rate that will allow the hooks to reach a depth of at least 10 m while under the aerial coverage of a well constructed bird-scaring line (Fig. 9) (Petersen *et al.* 2004). If implemented properly these measures should allow fishers to avoid the majority of seabird interactions, particularly with the more threatened albatross species occurring within the IOTC convention area. At present most vessels operating in South African waters are using 60 g swivels.

Integrated weighted line has been tested in autoline demersal longline fisheries and found to significantly increase line sink rates (Robertson *et al.* 2004). At present this mitigation measure has not been refined for pelagic longlines.

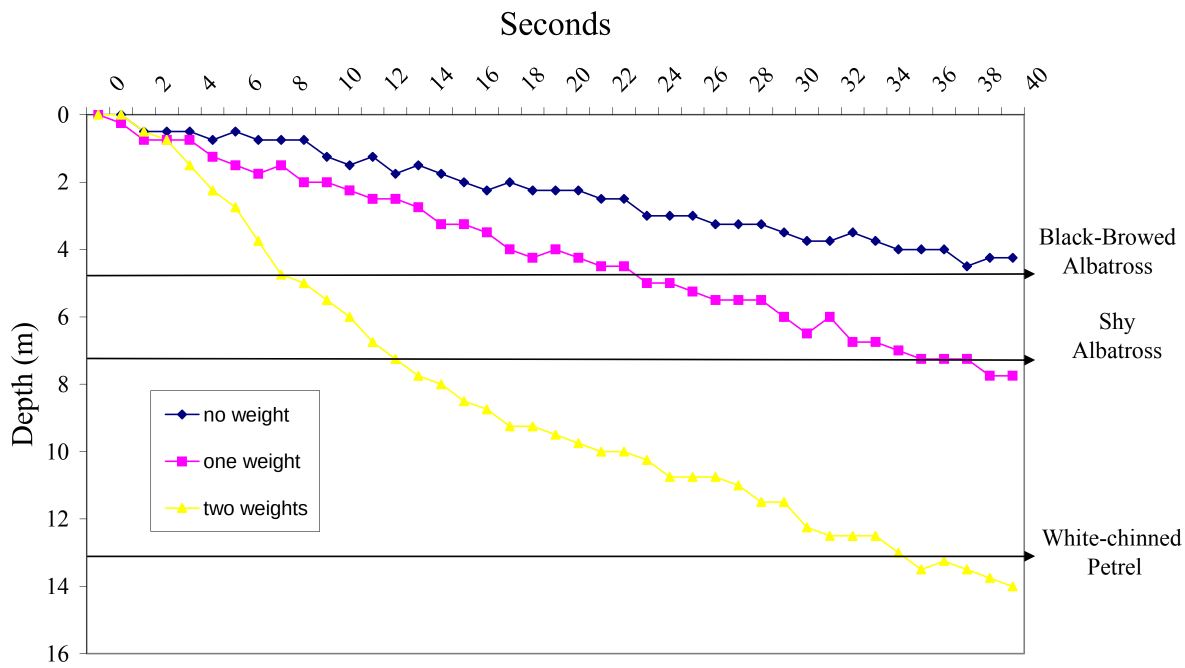

Figure 9: Sink rates of pelagic longline branchlines under different weighting regimes: no weight, one weight (60 g) and two weights (120 g) at a setting speed of 8 knots

4. Setting hooks below the surface using a stern tube

An underwater setting shoot has been developed to set baited hooks below the surface. This involves a funnel fitted to the stern of the vessel which guides the line directly from the vessel to below the surface (Ryan & Watkins 2001, Gilman *et al.* 2003). The system is still in the development phase and is not widely used.

Compliance to mitigation measures remains extremely low, even when vessels are carrying observers. This is cause for great concern and is in need of urgent redress. Low compliance experienced in the South African fishery is most likely the result of three factors. Firstly mitigation measures have been poorly defined. For instance, "the main line and branch lines (snood) must be properly weighted to ensure optimal sinking rates", but what constitutes "properly weighted" is unclear. Secondly, there has been little or no enforcement and where mitigation measures have been enforced litigation was unsuccessful due to the poorly defined wording in the permit condition. Thirdly, there is low awareness among fishers. This is largely due to the fact that previously there have been few resources available to engage fishers effectively and make them fully aware of the dire conservation status of the affected species, the urgent need to employ simple, cost-effective mitigation measures, as well as the economic benefits of reducing bait loss. Furthermore, in the past fishers have had little opportunity to be part of the thinking and decision-making process regarding mitigation. This has led to low levels of fisher buy-in and hence low levels of compliance. IOTC is in a position to take advantage of lessons learnt from the South African experience and thus avoid or at least reduce issues of low compliance.

5.2 Turtles

Of the five species reported to occur in south western Indian Ocean, four of these were caught (Loggerhead 39%, Leatherback 23%, Green 3%, Hawksbill 3%, unidentified 32%). Only the Olive Ridley was not recorded caught in this fishery. All four species caught are of conservation concern.

Table 5. Catch rates of turtles caught per bioregion (domestic vessels)

BIOREGION	2000	2001	2002	2003	All years
Agulhas inshore	0.13 (69)	0 (0)	0.10 (6)	0 (0)	0.09 (75)
Agulhas offshore	0 (0)	0.17 (6)	0 (0)	0 (0)	0.02 (6)
Delagoa inshore	-	-	0 (0)	0 (0)	0 (0)
Delagoa offshore	-	-	-	0 (0)	0 (0)
Natal inshore	-	0.06 (0)	0.3 (20)	0.07 (12)	0.13 (32)
Natal offshore	0 (0)	0.02 (0)	0.11 (5)	0.07 (12)	0.08 (17)
Average catch rate	0.04	0.06	0.1	0.02	0.05

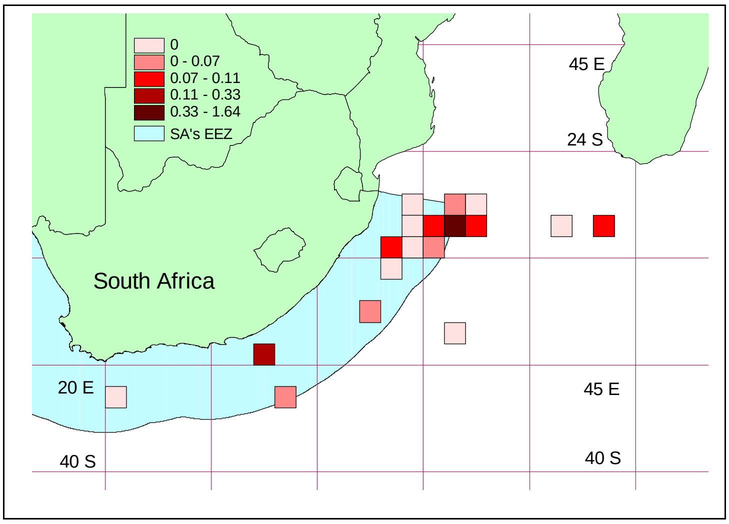

Figure 10. Catch rates of turtles by domestic vessels per one degree grid square (2000-2003)

Catch rates averaged 0.05 turtles per 1000 hooks or 1 turtle per 22 000 hooks (Table 5) and ranged between 0 and 1.6 turtles/1000 hooks per one degree grid square (Fig. 10). Most (55%) trips caught no turtles and 25 % of trips caught one turtle. However, there were trips where up to 35 turtles were caught (14 sets) and up to 10 turtles in a single set. It is likely that these incidents occur each year, but go undetected due to low observer coverage and as a result estimates in this study are likely to be an underestimate. In 85 % of cases turtles were alive. The use of appropriate de-hooking and release techniques will therefore decrease the impact this fishery is likely to have on these species.

There has been a global recognition of the threat longline fishing poses to turtle populations. All species are vulnerable to fisheries bycatch, with Leatherback and Loggerhead turtles being particularly vulnerable elsewhere in the world (Chan *et al.* 1988, Chaloupka & Limpus 2001, Pinedo & Polacheck 2003, Carreras *et al.* 2003, Lewison *et al.* 2004). It has been estimated that over 200 000 Loggerheads and 50 000 Leatherbacks are killed in pelagic longline fishing gear each year worldwide (Lewison *et al.* 2004). In 2000 an estimated 22 000-40 000 turtles were killed in the Pacific, 250-10 0000 in the Mediterranean, 30 000-60 000 in the Atlantic and 4000 in the Indian Ocean. There have been up to 95% decline in population numbers of Loggerhead and Leatherback turtles in the Pacific over the past 20 years (Lewison *et al.* 2004). Turtle bycatch in the South African domestic fleet accounts for 0.07-1% and 0.07-0.3% of the global bycatch estimate for Loggerhead and Leatherback turtles, respectively. Since all the species caught are of conservation concern this level of interaction is considered too high.

No mitigation measures have been tested under local conditions nor are they a condition of the permit to fish in the South African pelagic longline fishery. Mitigation trials have been proposed to be conducted in 2005/6 and include the testing of circle hooks as well as bait and gear manipulations. The patchy distribution of catches may however result in small sample sizes. It is also important to estimate post-release survival. This can be accomplished through a tag and release programme. Data collection protocols should include measurements of carapaces where practical and an estimate of size or weight where it is not practical to bring the animal on board. This is important to determine the age class of turtles caught by longliners. It is also essential to ensure species identification is accurate and to record the status of the animal when it is landed.

Preliminary mitigation studies conducted elsewhere in the world have shown that by using large 18/0 circle hooks and setting gear below 40 m can reduce turtle bycatch significantly and may increase catch-per-unit-effort (CPUE) of directed fisheries (Watson *et al.* 2003). A significant reduction in Loggerhead catch may be achieved by reducing daylight soak time. 18/0 circle hooks and mackerel bait were found to significantly reduce both Loggerhead and Leatherback turtle interactions when compared with J-hooks and squid bait. Moreover, circle hooks significantly reduced the rate of hook ingestion by the Loggerheads, reducing post-hooking mortality. The combination of 18/0 circle hooks and mackerel bait was found to be the most efficient mitigation measure for both Loggerhead (92% decrease) and Leatherback (67% decrease) turtles (Watson *et al.* 2003). More research and commercial demonstrations are needed, however. For some fisheries large hooks and deeper setting may not be economically viable.

Suggested mitigation measures are discussed in turn:

1. Circle hook

Hard-shelled turtles are most often caught by ingesting a hook whereas soft-shelled (e.g. Leatherback) turtles tend to get entangled in gear or hooked in their body (Watson *et al.* 2003).

The wider the hook, the less likely a turtle will be able to swallow it. When it is swallowed, circle hooks are more likely to hook turtles in the mouth, versus being hooked deeply as typically occurs with J hooks. If the turtle is still alive when gear is retrieved, they are more likely to survive being hooked in the mouth (because it's easier to remove the hook) than those hooked more deeply. Circle hooks have been shown to cause fewer hookings to the turtles' body than J and tuna hooks (Watson *et al.* 2003).

How does using the circle hook affect catches? In the U.S. Atlantic longline swordfish fishery, using 18/0 circle hooks with mackerel bait improved swordfish CPUE (30% increase), but an 81% decrease in Bigeye Tuna CPUE compared to fishing with conventional 25 degree offset 9/0 J hooks with squid bait (Watson *et al.* 2003). When using 18/0 circle hooks with squid bait there was a nominal increase in Bigeye Tuna CPUE and a decreased in swordfish CPUE (33 % decrease) (Watson *et al.* 2003).

2. Hooks should be removed

Vessels should also be encouraged to remove hooks from turtles. Commercial de-hooking kits are available (www.dehooker4arc.com).

3. Set gear deeper than 40 m

At present South Africa's domestic pelagic fleet sets its gear at relatively shallow depths (average 42 m) increasing the risk of catching turtles. By setting the gear as deep as possible interactions with turtles will be minimized. One should avoid placing branchlines near floats. To minimize the risk of entangling turtles, the amount of gear between 0-40 m should be kept to a minimum. This can be achieved by increasing the length of buoy lines rather than having short buoy lines and longer branch lines (Watson *et al.* 2003). This is may not be practical for those vessel targeting swordfish because its likely to reduce their CPUE.

4. Avoid problem areas

Turtle interactions in South African waters are generally a rare event. However, it appears that when they are caught, they are caught in large numbers. For example, one 14-day trip in February 2002 caught 33 turtles, and 46% of the turtles caught over the four year time period were from only three trips. All these trips occurred on the high seas between 10-15 degrees south and 25-30 degrees east. Therefore an important practice for preventing this level of incidental mortality is to move to new fishing grounds if a turtle is caught. Such a vessel should be encouraged to inform other vessels of the position of the turtle capture so they can avoid the area. Avoiding fishing in areas where high numbers of turtles occur, such as near turtle nesting beaches (e.g. north coast of KwaZulu-Natal, South Africa and Mozambique), will also reduce incidental capture. Present permit conditions do not allow longline fishing operations to occur within 18nm from the KwaZulu-Natal coast. A closed season or closed area might reduce current turtle bycatch.

5. Bait

There is some evidence to support that using fish bait instead of squid reduces turtle capture (Watson *et al.* 2003). Fish tends to come free of the hook while being eaten in small bites by a turtle compared to squid which holds more firmly to the hook. As a result turtles tend not to ingest the hook. The size of the bait may also limit turtle capture (Watson *et al.* 2003).

5.3 Sharks

Blue and Mako sharks comprised 60 % (range 3-100%) and 15 % (0-100%) of the shark bycatch respectively. The remaining 25% was made up of Bronze Whaler, Cookie Cutter, Crocodile, Dusky, Oceanic Whitetip, Porbeagle, Dog Tooth, Thresher, Bigeye Thresher, hammerheads (smooth, scalloped and great) and Zambezi Sharks. Although Blue Sharks were the most frequently caught, they were mainly discarded, often after being finned. Observers reported 30% and 25% of Blue Shark catches were finned in 2000 and 2001, respectively. Mako Sharks were also frequently caught and most commonly the whole shark was retained. Thresher Sharks were infrequently caught and equally discarded/released and retained. The Bronze Whaler was infrequently caught, but when it was caught it was usually retained. Crocodile, Cookie Cutter, Dusky (likely to include mis-identified Silky Sharks *C. falciformis*), Oceanic Whitetip, Dog Tooth, Bigeye Thresher, hammerhead spp. and Porbeagle sharks were infrequently caught, but almost always discarded/released. Even though the Crocodile Shark was caught infrequently, there were some occasions when they were caught in large numbers (e.g. a maximum of 81 was caught in a single set). The Zambezi Shark was rarely caught (only two individuals between 2000-2003) and in both cases it was discarded/released. Observers did not record whether sharks were hauled onboard dead or alive.

Sharks were caught on every set and catch rates averaged 7 sharks/1000 hooks (Table 7) and ranged between 0 and 65 per 1000 hooks (Fig. 11). Blue sharks were caught on most (87%) of sets and catch rates averaged 3.3 Blue Sharks/1000 hooks (range 0-65) (Fig.12, Table 7). Mako catches averaged 1.3/1000 hooks (range: 0-2.1) (Fig. 13, Table 8).

Table 6. Catch rates of sharks caught per bioregion (domestic vessels)

BIOREGION	2000	2001	2002	2003	All years
Agulhas inshore	2.73 (1388)	12.56 (741)	9.81 (584)	22.5 (3211)	11.9 (9443)
Agulhas offshore	1.09 (80)	5.07 (189)	17.34 (648)	7.33 (775)	7.7 (1997)
Delagoa inshore	-	-	-	4.42 (748)	4.4 (3074)
Delagoa offshore	-	-	6.33 (253)	4.47 (769)	5.4 (10467)
Natal inshore	-	1.93 (57)	6.84 (2374)	6.80 (1932)	6.8 (1240)
Natal offshore	0 (0)	3.78 (889)	10.16 (8148)	5.75 (4939)	4.9 (1073)
Average catch rate	1.3	5.8	10.1	8.6	6.7

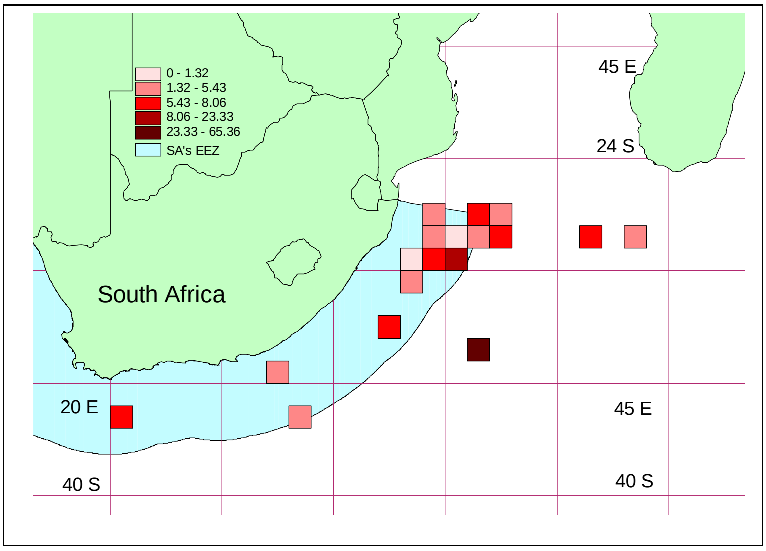

Figure 11. Catch rates of sharks by domestic vessels per one degree grid square (2000-2003)

Table 7. Catch rates of Blue Sharks caught per bioregion (domestic vessels)

BIOREGION	2000	2001	2002	2003	All years
Agulhas inshore	1.72 (875)	4.82 (284)	4.67 (278)	19.5 (2783)	7.7 (6110)
Agulhas offshore	0.5 (38)	3.17 (118)	5.55 (207)	4.67 (493)	3.5 (908)
Delagoa inshore	-	-	-	2.23 (378)	2.2 (1551)
Delagoa offshore	-	-	1.83 (73)	2.96 (509)	2.4 (4652)
Natal inshore	-	0.32 (10)	2.45 (849)	3.54 (1004)	2.1 (501)
Natal offshore	0	1.09 (256)	2.58 (2069)	2.88 (2469)	1.6 (350)
Average catch rate	0.7	2.5	3.4	6	3.3

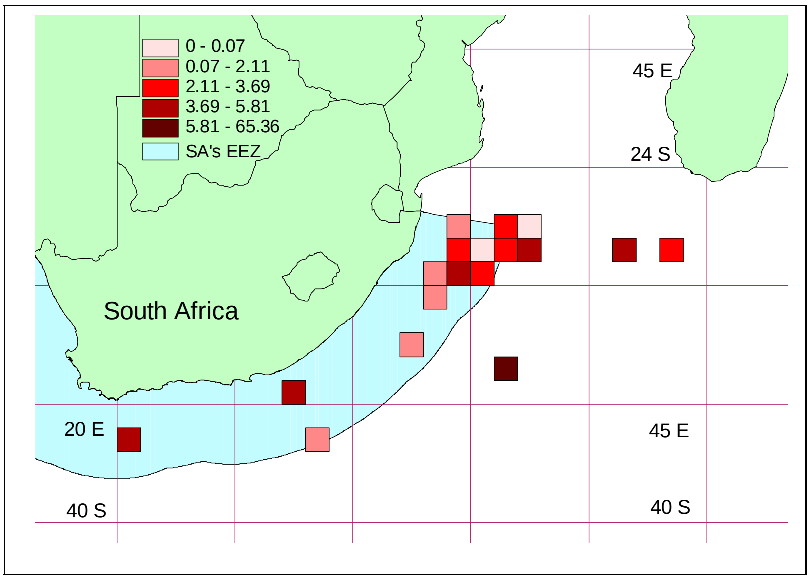

Figure 12. Catch rates of Blue Sharks by domestic vessels per one degree grid square (2000-2003)

Table 8. Catch rates of Mako Sharks caught per bioregion (domestic vessels)

BIOREGION	2000	2001	2002	2003	All years
Agulhas inshore	0.88 (465)	7.36 (436)	3.9 (242)	2.5 (361)	3.7 (2936)
Agulhas offshore	0.45 (238)	1.84 (69)	11.45 (445)	0 (0)	3.4 (882)
Delagoa inshore	-	-	-	0.09 (15)	0.09 (63)
Delagoa offshore	-	-	0 (0)	0.14 (24)	0.07 (136)
Natal offshore	-	0.21 (6)	0.53 (191)	0.38 (109)	0.37 (88)
Natal inshore	0 (0)	0.45 (106)	0.3 (250)	0.27 (234)	0.26 (50)
Average catch rate	0.4	2.5	3.2	0.56	1.3

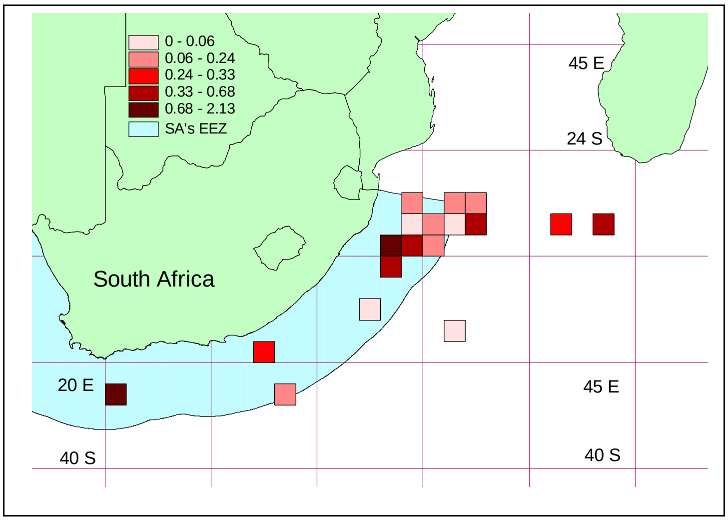

Figure 12. Catch rates of Mako sharks by domestic vessels per one degree grid square (2000-2003)

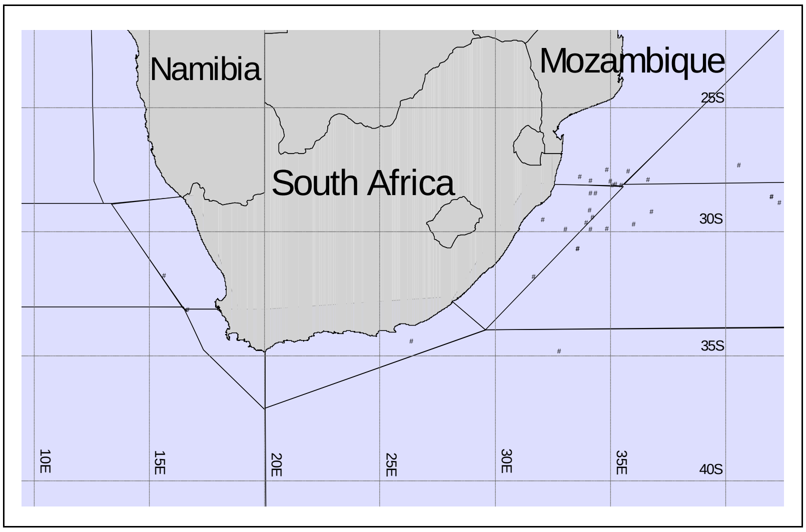

Figure 13: Distribution of sets on which Oceanic Whitetip Sharks were caught, 2000-2003

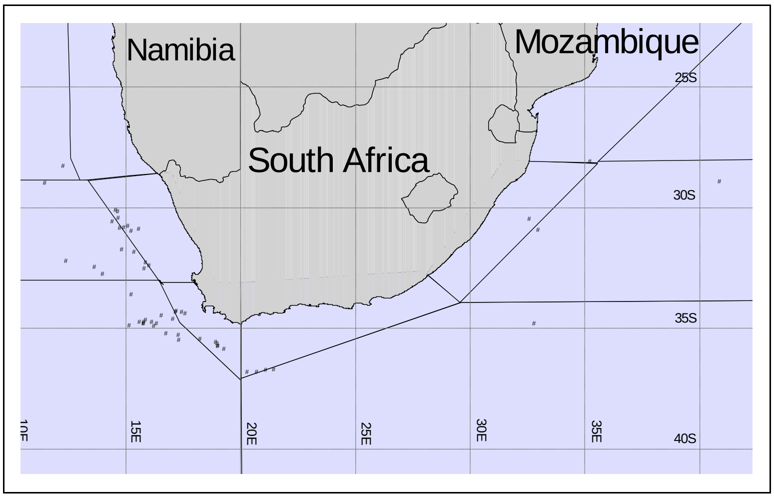

Figure 14: Distribution of sets on which Thresher Sharks were caught, 2000-2003

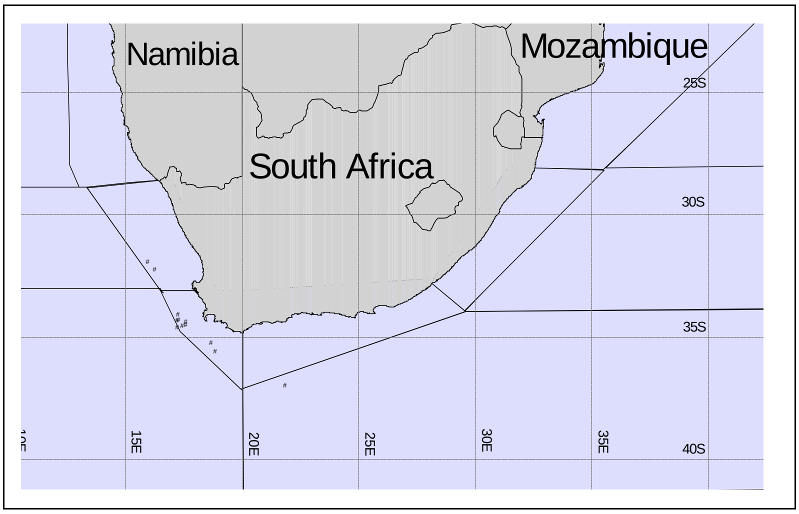

Figure 15: Distribution of sets of which Bigeye Thresher Sharks were caught, 2000-2003

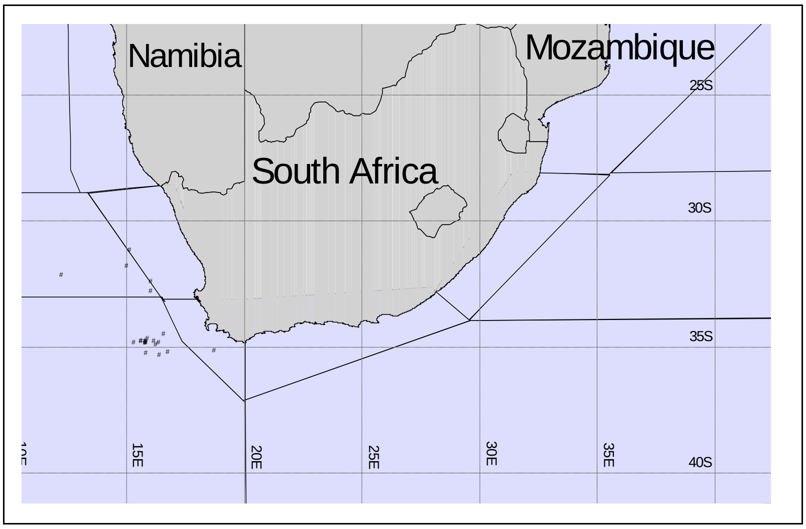

Figure 16: Distribution of sets on which Porbeagle Sharks were caught, 2000-2003

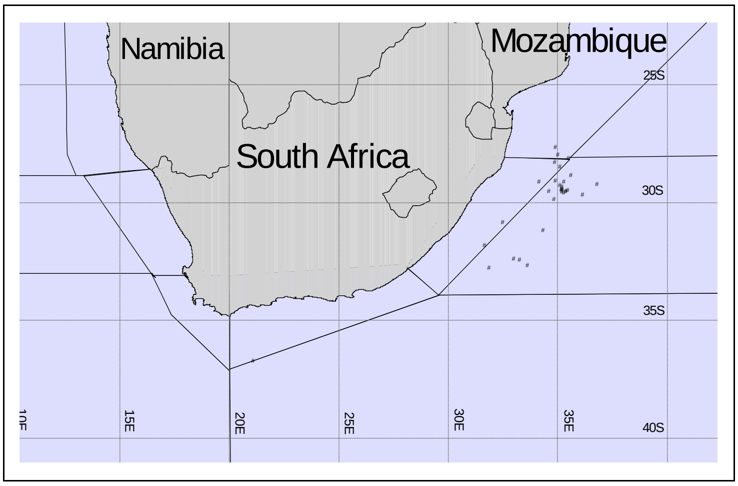

Figure 17: Distribution of sets on which hammerheads were caught, 2000-2003

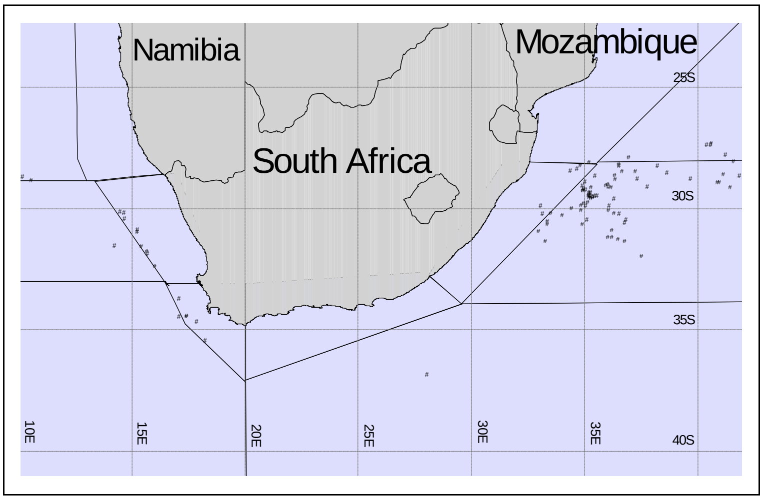

Figure 18: Distribution of sets on which Crocodile Sharks were caught, 2000-2003

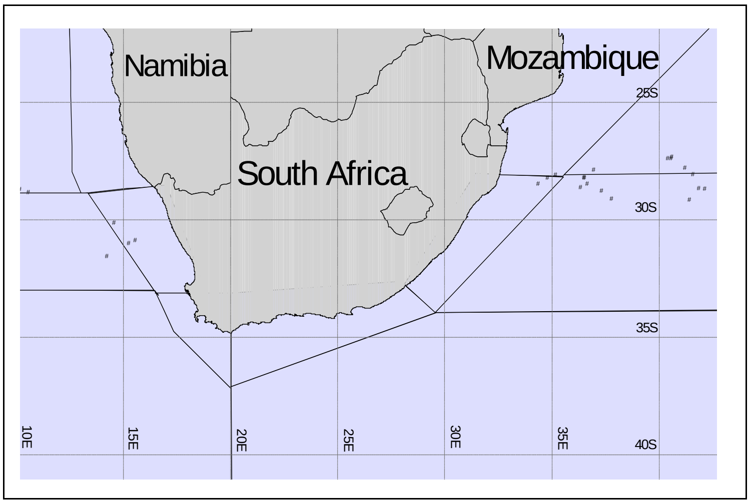

Figure 19: Distribution of sets on which Cookie Cutter Sharks were caught, 2000-2003

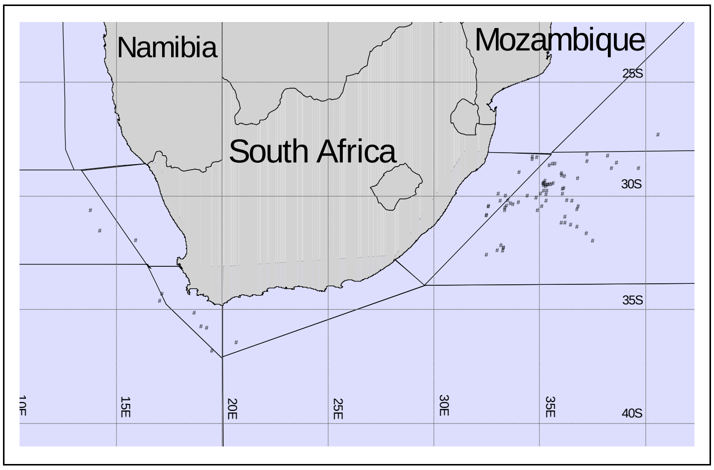

Figure 20: Distribution of sets on which Bronze Whaler Sharks were caught, 2000-2003

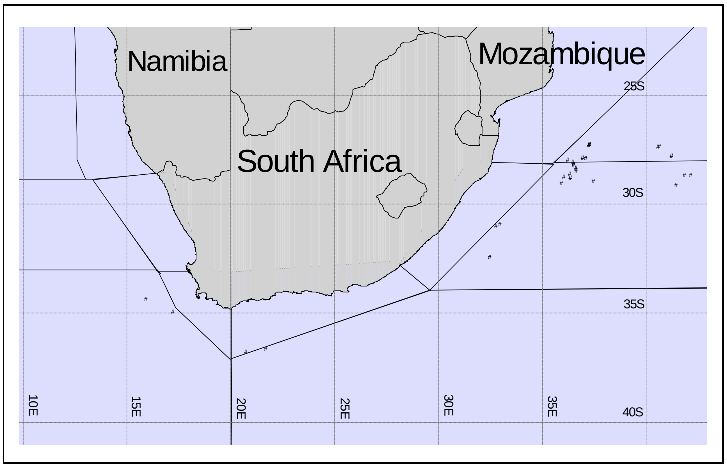

Figure 21: Distribution of sets on which Dusky Sharks were caught, 2000-2003

Bycatch is a known global threat for the following species (Blue, Mako, Hammerhead spp., Thresher, Crocodile, Porbeagle). However, little is known of the status of most of these stocks. In many cases the IUCN redlist merely states "data deficient". Is this level of mortality biologically consequential? Current data are insufficient to adequately assess the effect of fishing pressure on length frequency or CPUE. A short time series of length frequency data for Blue Sharks is presented in Figure 22. An equally pertinent question is what are the knock-on effects of removing this number of top predators? In short, we simply do not know. In view of these data deficiencies the precautionary principle should be invoked and research highlighted as a top priority. A tag and release programme should be implemented in order to estimate post-release survival.

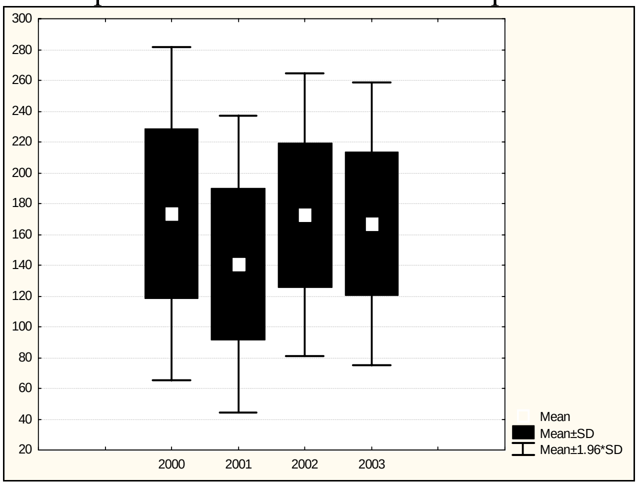

Figure 22: Length frequencies of Blue Sharks, 2000-2003

At present there are no accepted mitigation measures for reducing shark bycatch and this requires investigation. South Africa is addressing the mounting international concern for high levels of shark bycatch by closing the pelagic sector of the shark-directed longline fishery and placing a 10% shark bycatch limit on the tuna and swordfish fishery. Currently shark bycatch accounts for approximately 29% (0-100%) of the directed catch (Table 9). This is substantially larger than the suggested 10%, thus many of these shark species will be released or discarded. Since we have no estimate of post-release survival nor adequate information on the percentage of species hauled alive, this measure may not alleviate the pressure currently placed on the concerned stocks.

Table 9: Shark bycatch as a proportion of total catch

Year	% sharks of total catch	min %	max %	Std Deviation	No of trips	No of sets
2002	34%	3%	100%	26%	10	74
2003	25%	0%	92%	19%	12	145
Total	29%	0%	100%	22%	22	219

Five actions are suggested to address shark bycatch: firstly, an effort should be made to assess the stock of at least the two most commonly caught species, namely Blue and Mako sharks. This is essential in order to evaluate whether the current levels of mortality are sustainable. Secondly, post-release survival needs to be estimated. This can be achieved through a tag and release programme. Thirdly, data collection should be improved both in terms of what data should be collected and the skills of the data collector/observer. Data collection protocols should include whether the sharks are dead or alive, whether the hook is left in the animal or not as well as length frequency measurements. Species identification also needs to be improved. Fourthly research of shark mitigation measures should be highlighted as a need and fifthly, regional plans of action based on FAO IPOA-sharks should be completed and implemented as a matter of urgency.

6. Conclusions

Our data show that bycatch levels within the South Western Indian Ocean warrant concern.

Data collection through observer programmes

Observer coverage should be increased within the IOTC convention area. This is best achieved by implementing a regional observer programme with defined observer standards. The CCAMLR experience has shown the importance of centrally collated and managed data, collected by independent observers. Bycatch data should also be highlighted as a priority within existing country observer programmes. The value of this data should be communicated to observers, who should receive the appropriate training and briefing prior to departure. Trips dedicated to the collection of bycatch data or at least dedicated periods of time per set or trip will also improve the quality of the data.

Besides from collecting verifiable data, fishery observers can play an important role in educating and raising awareness of the nature and extent of the problem to the fishing industry. A thorough knowledge and understanding of mitigation measures is thus imperative and must form part of their routine briefing.

We therefore encourage IOTC to adopt a framework through which all Parties shall collect and report bycatch data, as well as information on the performance of mitigation measures.

Sharks

The lack of data on the catch and bycatch of sharks throughout the Indian Ocean is of concern. The inadequacy of research and monitoring activity targeted at sharks and the consequent lack of data on which to base assessments of threat, to identify critical habitats and to make recommendations for sustainable harvesting strategies, currently makes it challenging to manage sharks within the Indian Ocean. In view of data scarcity, scientists are best placed to provide advice that will inform the implementation of appropriate precautionary measures. Appropriate steps should be put in place in order to conduct stock assessments of key bycatch species in the near future. However, the shortage of scientific data should not delay the implementation of management interventions. We strongly encourage the IOTC to take the opportunity to generate at least preliminary advice upon which to take firm management action and encourage IOTC to be guided by the FAO IPOA-Sharks.

Turtles

We encourage IOTC to assess the impact of different gear types and fishing practices on turtles in the Indian Ocean. Significant efforts have been made in some areas and that greater collaboration will see practical and effective mitigation measures adopted more widely. Results from trials of new gear types, such as circle hooks, in other fisheries will be a significant relevance to the fisheries in the Indian Ocean.

Seabirds

We believe stronger and more comprehensive resolutions are needed and should include the adoption of mitigation measures, at least south of 30 degrees.

Invitation of collaboration

We would like to encourage IOTC to consider working in partnership with NGOs, Parties and other regional fisheries management organizations, such as CCAMLR, in order to achieve the above mentioned goals, specifically the implementation observer programmes, bycatch mitigation trials and other conservation initiatives. For example, awareness and training materials have been developed elsewhere and could be effectively used by IOTC.

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Appendix 1: IOTC Resolution on 05/05 concerning the conservation of sharks caught in association with fisheries managed by IOTC (Adopted 2005)

The Indian Ocean Tuna Commission (IOTC),

RECALLING that the United Nations Food and Agriculture Organisation (FAO) International Plan of Action of Sharks calls on States, within the framework of their respective competencies and consistent with international law, to cooperate through regional fisheries organisations with a view to ensuring the sustainability of shark stocks as well as to adopt a National Plan of Action for the conservation and management of sharks (defined as elasmobranchs);
CONSIDERING that many sharks are part of pelagic ecosystems in the IOTC area, and that tunas and tuna-like species are captured in fisheries targeting sharks;
RECOGNISING the need to collect data on catch, effort, discards and trade, as well as information on the biological parameters of many species, in order to conserve and manage sharks;

ADOPTS, in accordance with paragraph 1 of Article IX of the IOTC Agreement that:

1. Contracting Parties, Cooperating non-Contracting Parties (CPCs) shall annually report data for catches of sharks, in accordance with IOTC data reporting procedures, including available historical data.
2. In 2006 the Scientific Committee (in collaboration with the Working Party on Bycatch) provide preliminary advice on the stock status of key shark species and propose a research plan and timeline for a comprehensive assessment of these stocks.
3. CPCs shall take the necessary measures to require that their fishermen fully utilise their entire catches of sharks. Full utilisation is defined as retention by the fishing vessel of all parts of the shark excepting head, guts and skins, to the point of first landing.
4. CPCs shall require their vessels to not have onboard fins that total more than 5 % of the weight of sharks onboard, up to the first point of landing. CPCs that currently do not require fins and carcasses to be offloaded together at the point of first landing shall take the necessary measures to ensure compliance with the 5 % ratio through certification, monitoring by an observer, or other appropriate measures.
5. The ratio of fin-to-body weight of sharks described in paragraph 4 shall be reviewed by the scientific committee and reported back to the Commission in 2006 for revision, if necessary.
6. Fishing vessels are prohibited from retaining on board, transhipping or landing any fins harvested in contravention of this Resolution.
7. In fisheries that are not directed at sharks, CPCs shall encourage the release of live sharks, especially juveniles and pregnant sharks, to the extent possible, that are caught incidentally and are not used for food and/or subsistence.
8. CPCs shall, where possible, undertake research to identify ways to make fishing gears more selective (such as the implications of avoiding the use of wire traces).
9. CPCs shall, where possible, conduct research to identify shark nursery areas.
10. The Commission shall consider appropriate assistance to developing CPCs for the collection of data on their shark catches.
11. This resolution applies only to sharks caught in association with fisheries managed by the IOTC.
12. This provision to apply without prejudice to many artisanal fisheries which traditionally do not discard carcasses.

Appendix 2: Recommendation 05/09 on incidental mortality of seabirds

The Indian Ocean Tuna Commission (IOTC),

TAKING INTO ACCOUNT the FAO International Plan of Action for Reducing the Incidental Catch of Seabirds in Longline Fisheries;

RECOGNISING the need to evaluate the incidental mortality of seabirds during longline fishing operations for tunas and tuna-like species;

NOTING that fisheries other than longline fisheries targeting tuna and tuna-like species may also contribute to the incidental mortality of seabirds;

FURTHER NOTING that other factors, such as swallowing marine debris, are also responsible for seabird mortality.

RECOMMENDS, in accordance with paragraph 8 of Article IX of the Agreement, that:

1. Contracting Parties and Cooperating non-Contracting Parties (hereinafter referred to as "CPCs") should inform the Scientific Committee, if appropriate, and the Commission of the status of their National Plans of Action for Reducing Incidental Catches of Seabirds in Longline Fisheries. The Commission should urge CPCs to implement, if appropriate, the International Plan of Action for Reducing Incidental Catches of Seabirds in Longline Fisheries if they have not yet done so.
2. CPCs should be encouraged to collect and voluntarily provide Scientific Committee with all available information on interactions with seabirds, including incidental catches in all fisheries under the purview of IOTC.
3. When feasible and appropriate, Scientific Committee should present to the Commission an assessment of the impact of incidental catch of seabirds resulting from the activities of all the vessels fishing for tunas and tuna-like species, in the IOTC Area.
4. CPCs are encouraged to support developing countries in their implementing the Guidelines.

Appendix 3: Recommendation 05/08 on sea turtles

The Indian Ocean Tuna Commission (IOTC),

NOTING the need to improve the collection of scientific data regarding all sources of mortality for sea turtle populations, including but not limited to, data from fisheries within the IOTC Area to enhance the proper conservation of sea turtles;
RECOGNISING that at the 26th FAO-COFI Session in March 2005, the Guidelines to Reduce Sea Turtle Mortality in Fishing Operation (hereinafter referred to as "the Guidelines") was adopted,
ACKNOWLEDGING the activities undertaken to conserve marine turtles and the habitats on which they depend, within the framework of the Indian Ocean – South-East Asian Marine Turtle Memorandum of Understanding (IOSEA MoU); noting the decision of the 22 IOSEA Signatory States to establish a voluntary reporting mechanism to monitor implementation of the Guidelines; and noting further IOSEA MoU Resolution 3.1 regarding collaboration with IOTC on marine turtle by-catch issues;
RECOMMENDS, in accordance with paragraph 8 of Article IX of the IOTC Agreement, that: 1. The Commission encourages Contracting Parties and Cooperating non-Contracting Parties (hereinafter referred to as "CPCs") to implement the Guidelines, inter alia, the necessary measures for vessels fishing for tuna and tuna-like species in the IOTC Area to mitigate the impact of fishing operations on sea turtles:

A. General
1. Requirements for appropriate handling, including resuscitation or prompt release of all bycaught or incidentally caught (hooked or entangled) sea turtles.
2. Retention and use of necessary equipment for appropriate release of bycaught or incidentally caught sea turtles.

B. Purse seine
1. Avoid encirclement of sea turtles to the extent practical.
2. Develop and implement appropriate gear specifications to minimize bycatch of sea turtles.
3. If encircled or entangled, take all possible measures to safely release sea turtles.
4. For fish aggregating devices (FADs) that may entangle sea turtles, take necessary measures to monitor FADs and release entangled sea turtles, and recover these FADs when not in use.

C. Longline
1. Development and implementation of appropriate combinations of hook design, type of bait, depth, gear specifications and fishing practices in order to minimize bycatch or incidental catch and mortality of sea turtles.
2. Retention and use of necessary equipment for appropriate release of bycaught and incidentally caught sea turtles, including de-hooking, line cutting tools and scoop nets.
3. The Commission encourages CPCs to collect and voluntarily provide the Scientific Committee with all available information on interactions with sea turtles in fisheries targeting the species covered by the IOTC Agreement, including successful mitigation measures, incidental catches and other impacts on sea turtles in the IOTC Area, such as the deterioration of nesting sites and swallowing of marine debris.
4. Encourages CPCs to coordinate their respective IOTC and IOSEA implementation measures, where applicable; and urges the respective secretariats to intensify their collaboration and exchange of information in this area.
5. CPCs are encouraged to support developing countries in their implementing the Guidelines