THE IMPACT OF LONGLINE FISHERIES ON SEABIRDS IN THE BENGUELA CURRENT LARGE MARINE ECOSYSTEM

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SUMMARY

The Benguela current provides rich foraging for sub-Antarctic pelagic birds as well as a number of endemic seabird species. Interaction with longline fishing practises have been identified as the primary cause of seabird population declines. This study represents the first attempt at quantifying seabird by-catch in the Benguela Current Large Marine Ecosystem. By-catch rates for South African fisheries were 0.2 and 0.04 birds per 1000 hooks in the pelagic and demersal longline fishery respectively, totalling an average of 500 birds killed per year. Namibian longline fisheries were estimated to kill approximately 0.07 bird per 1000 hooks in the pelagic longline fishery and 0.3 birds per 1000 hooks in the demersal longline fishery. Together Namibian longline fisheries are likely to kill approximately 14 900 birds per year. Limited data exist for Angolan pelagic longline and artisanal line fisheries both of which overlap with vulnerable seabird populations. White-chinned petrels and gannets are recorded caught as directed catch of the artisanal line fishery for consumption. Estimates for the entire region were based on pelagic longline effort which averaged 34.5 million hooks per year. This fishery is likely to be killing approximately 2 900 bird per year. Thus a total of 17 800 birds are estimated to be killed per year by longline fisheries operating throughout the region.

RÉSUMÉ

Le Benguela constitue actuellement une riche zone trophique pour les oiseaux pélagiques sous-antarctiques ainsi que pour de nombreuses espèces endémiques d'oiseaux de mer. L'interaction avec les activités de la pêche palangrière a été identifiée comme la principale cause du déclin des populations d'oiseaux de mer. Cette étude est la première tentative de quantification des prises accessoires d'oiseaux de mer dans le Grand écosystème marin du Benguela. Les taux de prises accessoires des pêcheries sud-africaines s'élevaient à 0,2 et 0,04 oiseaux par 1.000 hameçons dans la pêcherie palangrière pélagique et démersale, respectivement, soit une moyenne de 500 oiseaux tués par an. Il a été estimé que les pêcheries palangrières pélagiques namibiennes tuaient environ 0,07 oiseaux par 1.000 hameçons et que les pêcheries palangrières démersales namibiennes tuaient 0,3 oiseaux par 1.000 hameçons. Dans leur ensemble, les pêcheries palangrières namibiennes, pourraient tuer près de 14.900 oiseaux par an. Des données limitées existent pour les pêcheries palangrières pélagiques et les pêcheries artisanales à la ligne à main angolaises, qui interagissent toutes deux avec les populations vulnérables d'oiseaux de mer. Les puffins à menton blanc et les fous de Bassan sont capturés en tant que prise directe de la pêcherie artisanale à la ligne à main aux fins de consommation. Les estimations de l'ensemble de la région se basaient sur l'effort palangrier pélagique, soit 34,5 millions d'hameçons par an en moyenne. Cette pêcherie tue probablement près de 2.900 oiseaux par an. On estime donc que les pêcheries palangrières opérant dans toute la région tuent, au total, 17.800 oiseaux chaque année.

RESUMEN

El ecosistema de Benguela proporciona una zona rica en forraje para las aves pelágicas subantárticas, así como para un gran número de especies de aves marinas endémicas. Se ha identificado la interacción con las prácticas de pesca al palangre como la causa principal de los descensos de las poblaciones de aves marinas. Este estudio supone el primer intento de cuantificar la captura fortuita de aves marinas en el amplio ecosistema marino de Benguela. Las tasas de captura fortuita de las pesquerías sudafricanas se situaron en 0,2 y 0,04 aves por 1.000 anzuelos en la pesquería palangrera pelágica y demersal, respectivamente, lo que asciende a un promedio de unas 500 aves muertas por año. Se estimó que las pesquerías palangreras namibias mataron aproximadamente 0,07 aves por 1.000 anzuelos en las pesquerías pelágicas y 0,3 aves por 1.000 anzuelos en las pesquerías demersales. Es probable que, en conjunto, las pesquerías pelágicas namibias maten aproximadamente 14.900 aves por año. Existen pocos datos para las pesquerías de caña artesanal y de palangre pelágico de Angola, aunque ambas coinciden con poblaciones vulnerables de aves marinas. Se han registrado capturas directas de petreles negros y alcatraces realizadas por la pesquería de caña artesanal con fines de consumo. Las estimaciones para la totalidad de la región se basan en el esfuerzo del palangre pelágico, que se sitúa en un promedio de 34,5 millones de anzuelos por año. Es probable que esta pesquería esté

matando aproximadamente 2.900 aves por año. Por tanto, se estima que la pesquería de palangre que opera en toda la región mata unas 17.800 aves por año.

1. Introduction

The incidental mortality of seabirds (otherwise known as bycatch) poses a serious conservation concern globally. The seabirds most affected by this threat are generally long lived and display delayed maturity and low reproductive rates. As a result, they are particularly vulnerable to even small increases in adult mortality (Croxall and Gales 1998, Gales 1998). This vulnerability to such rare and stochastic bycatch events complicates perceptions regarding the need for mitigation (Robertson 1998). 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. However, even these seemingly small numbers add up to significant numbers when they are considered for the entire fleet or the region. These impacts have been held responsible for population declines of several species of seabirds, especially albatrosses and petrels (Croxall and Gales 1998, Gales 1998).

The Benguela Current upwelling system is a very productive foraging area for juvenile, immature and over-wintering adult southern ocean seabirds (Ryan and Rose 1995). In fact 15 of the 24 species of albatross and petrels that are currently threatened with extinction, spend significant time foraging in southern African coastal waters (Nel and Taylor 2002). The Benguela Current is also home to a number of endemic seabirds most notably the cape gannet which is also impacted by fishing operations (Ryan and Rose 1995).

2. Occurrence of seabirds in the Benguela Current

The five migrant pelagic seabird species occurring in the Benguela Current that are most susceptible to the impacts of fishing operations are the black-browed albatross *(Thallasarche melanophris)*, shy albatross *(T. cauta)*, Atlantic yellow-nosed alabtross *(T. chlororhynchus)* and Indian yellow-nosed albatross *(T. carteri)* and the white-chinned petrel *(Procellaria aequinoctialis)*. Of the Benguela endemics, the cape gannet *(Morus capensis)* is the most susceptible to fisheries impacts. Abundance of all these species is the highest along the continental shelf and decreases in a northerly direction (Crawford *et al.* 1991 and Crawford *et al.* in press).

Similar species are also found in Angola but at even lower densities. Moving north from the Namibian border to 16ºS, many southern ocean species (shy, black-browed, and Atlantic yellow-nosed albatrosses, Cape petrels *Daption capense*, white-chinned petrels, sooty shearwaters *Puffinus griffeus*, and manx shearwaters *P. puffinus*) as well as Benguela current region endemics (cape gannet, cape cormorant *Phalacrocorax capensis*, kelp gull *Larus dominicanus*) are still found in significant numbers (Roux *et al.* 2005). Of the three species of albatrosses observed in Angolan waters, the Atlantic yellow-nosed albatross was by far the most abundant. North of 16ºʼS the numbers of seabirds decreased further, although Atlantic yellow-nosed albatrosses were still present in low numbers. The decrease in seabird densities was most significantly north of 14º30ʼS, however Sooty shearwaters *P. griseus* are present in oceanic waters and White-chinned petrels over the outer shelf and beyond in this region (Roux *et al.* 2005). Higher numbers of cape gannets were recorded in a small area between 11º10ʼS-11º15ʼS (the northwestern edge of the Quicombo bank).

Cape gannets *Morus Capensis* proved to be the most abundant seabird with high numbers occurring between 11ºS and 12ºS and south of 16ºS. About 1600 individuals were sighted of which about 60% were sub-adult birds, highlighting the importance of Angolan waters serving as a feeding and wintering area for these birds (Roux *et al.* 2005).

The Cape gannet is an endemic to the region with only six breeding sites worldwide, including three in Namibia. The Namibian population has declined in the past decade and the recruitment of young birds appears to be insufficient to sustain the population (Crawford *et al.* in press). Southern Angola may thus be a key area for conservation efforts concerning gannets (Roux *et al.* 2005). The Cape Gannet population is 134 000 in South Africa and 10 400 in Namibia (Crawford *et al.* in press).

3. Longline fisheries operating in the Benguela

There are currently two longline fisheries operating within the Benguela Current Large Marine Ecosystem: A demersal fishery targeting hake *Merluccius* spp. (South Africa and Namibia) and a pelagic longline fishery targeting tuna *Thunnus* spp., swordfish *Xiphias gladius* and pelagic sharks (South Africa, Namibia and Angola).

3.1 South African pelagic longline fishery

The earliest record of a South African domestic pelagic longline fishery dates back to the early 1960s (Cooper and Ryan 2005). This fishery predominantly targeted albacore *(Thunnus alalunga), s*outhern bluefin *(T. maccoyii)* and bigeye *(T. obesus)* tunas (Cooper and Ryan 2005). Effort in the domestic fishery waned in the mid 1960s. Thereafter, pelagic fishing effort was largely conducted by Japanese and Taiwanese vessels by way of separate bilateral agreements with South Africa. These Asian vessels set their gear relatively deeply, frequently set during the day, seldom used lightsticks and primarily targeted tuna species. Their fishing effort accounted for 96% of the *c.* 12 million hooks set annually within the South African EEZ during 1998-2000 (Ryan and Boix-Hinzen 1998, Ryan *et al.* 2002).

In 1995, a permit was issued to conduct a joint venture operation between a South African and Japanese vessel. This joint venture showed that tunas and swordfish could be profitably exploited in South African waters and consequently the South African government, issued 30 experimental permits in 1997 to South African flagged vessels. These vessels typically use the American longline system and set their gear relatively shallow, used lightsticks and set their lines primarily at night, thus targeting swordfish.

All foreign licences were revoked in 2002. This resulted in a smaller and domestic fishery operating in South Africa's Exclusive Economic Zone (EEZ), targeting primarily swordfish. However, the domestic fishery was further developed in 2004 when 50 commercial fishing rights were made available for allocation (30 tuna-directed and 20 swordfish-directed). Some of these rights were awarded to South African companies who employed Asian vessels (11 Korean and two Philippine) under joint venture contracts.

3.2 South African demersal longline fishery

An experimental demersal longline fishery targeting kingklip *(Genypterus capensis)* in the continental shelf waters around South Africa was initiated in 1983 (Barnes *et al*. 1997). Due to concern over the sustainability of the kingklip resource the fishery was closed in 1990. In 1994, a five-year experimental longline fishery directed at hakes *(Merluccius capensis)* (mainly inshore) and *M. paradoxus* (mainly offshore) was started. During this period the number of active vessels varied between 32 and 71, and annual fishing effort from 2.5 to 13.4 million hooks. In 1998, this fishery became commercial and has remained so until the present (Cooper and Ryan 2005).

3.3 Namibian pelagic longline fishery

Commercial longlining for tuna started in Namibia in 1968. After Namibia's independence in 1990, a Namibian-controlled tuna pole-and-line fishery started in 1991 (mostly for albacore) by a fleet of about 30 local and foreign-owned vessels. However, foreign longliners carried on catching tuna in Namibian waters under South African licenses after independence. A foreign longline tuna fishery started in 1993 targeting bigeye tuna for the high-value sashimi market. In 1996, an exploratory longline fishery for swordfish was initiated and has continued till the present. In April 2000, the Namibian Ministry of Fisheries and Marine Resources advised that the tuna pole-and-line and longline fishing rights would be replaced by a "large pelagic fishing" right. Holders of such rights may target tunas and other large pelagic species, including swordfish and other billfish as well as large pelagic sharks. During 2003, twenty longline vessels were active in this fishery. These vessels targeted mainly bigeye tune, swordfish, blue and mako sharks (Voges 2005).

3.4 Namibian demersal longline fishery

Hake longline fishery started in Namibia in 1991. The fleet initially comprised of 11 vessels. Over the years the number of vessels increased so that currently there are 25 active vessels. The gross registered tonnage (GRT) of the vessels vary from 65 to 483 GRT with an average of 188 GRT and the average horsepower (HP) is 665 with a range of between 228 and 1850 HP. The vessels are typically small wooden vessels with a length range of between 19 and 35 m and an average length of 27 m. Fishing takes place mainly between the 19°S and 30°S, at sea depths of 200 to 600 m (average 330 m). The typical trip is approximately 6 days duration. Six right holders currently share the hake longline quota. The annual quota for hake longliners is approximately 6% of the hake

total allowable catch (TAC) of around 180,000 tons. This resulted in landings by hake longliners of less than 8,000 tons for the past few years.

3.5 Angolan longline fisheries

There are three fisheries in Angola where seabird mortality is likely to occur namely in coastal artisanal subsistence fishing (vessels smaller than 10 metres) targeting line fish such a grouper, semi-industrial vessels (11-25 m) also targeting line fish and industrial longline fishing (larger than 25 m) targeting tuna, swordfish and pelagic sharks. Four types of line gear are used, namely: line fishery for tuna (trolling), pole and line fishery (720 tons per day and approximately 240 days per year, and handline (used by artisanal fishers mainly) and commercial longlines (Duarte 2005).

Although by-catch of seabirds in South African waters has been sporadically documented over the past few years (Barnes *et al.* 1997, Ryan and Boix-Hinzen 1998, Osbourne and Mullins 2002, Ryan *et al.* 2002), the scope of this work has been limited both geographically (i.e. to national and not ecological boundaries) and temporarily (usually only a year or two of data). This paper represents the first comprehensive attempt to evaluate the impact longline fisheries on the seabirds foraging within the Benguela Large Marine Ecosystem (BCLME). The impact of the South African and Namibian demersal and pelagic longline fleets on seabirds is calculated separately. Since numerous distant water fleets operate within the BCLME, the impact of these fleets was estimated from the South African and Namibian catch data and extrapolated for total effort obtained from ICCAT (International Commission for the Conservation of Atlantic Tunas). Management and research recommendations are made based on this information.

4. Methods

For the purposes of this analysis, the Benguela region has been defined as west of 20 degrees east, east of 0 degrees, north of 35ºS and South of 5ºS. Shannon and O'Toole (2003) described the eastern most boundary of the Benguela Current as 27ºE. However fisheries in South Africa are generally managed on the 20ºE longitude. The Regional Fisheries Management Organisations, ICCAT (International Commission for the Conservation of Atlantic Tunas) and IOTC (Indian Ocean Tuna Commission) are also divided along this boundary.

4.1 At-sea collection of data

Data were collected by fisheries observers in South Africa from 2000 to 2005. This information included seabird by-catch information (species, number and status), as well as gear (e.g. number of hooks, length of mainline, etc.) and operational (time of set and position, etc) information. No observer data are available from Namibia and Angola.

A specialised observer collected seabird by-catch and abundance data in South Africa and Namibia during 2005 and 2006 on board demersal and pelagic longline vessels. Six week-long trips were conducted on board a hake longliner in the months of April, October and November, 2005. Data for the swordfish longline fishery were collected during two trips in April and May 2006 on the west coast of South Africa. One trip was conducted on a pelagic longline vessel in Namibia in June, 2006.

Levels of by-catch (or catch rates) are reported as numbers of birds caught per 1000 hooks. This is calculated using the following formulae:

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

Where
$\hat{C}$ = Estimated total by-catch of a species, s.
C_{sr} = Observed by-catch 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 = Region

Seasons were defined as follows: summer = December - February, autumn = March -May, winter = June - August and spring = September - November.

4.2 Interviews

A questionnaire was developed and used to supplement data in Namibia. Interviewees were asked whether they had witnessed seabirds being caught on longlines. If so, they were required to estimate how many and which species were most frequently caught. They were further asked whether they thought the reported level of mortality was affecting seabird populations. Two skippers and 13 observers were interviewed.

Interviews were also conducted in the Angolan province of Namibe where information was collected on seabird by-catch in the artisanal fisheries. A field guide was used to aid the identification of the seabirds caught.

4.3 Effort data

To characterise pelagic longline effort within the Benguela Current Large Marine Ecosystem we used two sources of data. Firstly, we obtained observer and logsheet data detailing fishing effort and distribution for South Africa and Namibia. This type of data is lacking for Angola as the industrial vessels operating in these fleets are foreign flagged and use distant ports. Secondly, we obtained public domain data from the Regional Fisheries Management Organisation ICCAT (International Commission for the Conservation of Atlantic Tunas) from 2000 to 2004. Some manipulation and interpretation of the data were necessary because some nations reported effort, but no catch, and vice versa. In these cases, effort was estimated by using an average catch rate based on countries where both catch and effort were reported by 5 x 5 degree grid square. For extrapolating a total seabird mortality for the Benguela the effort is divided into three regions namely northern (between 5 and 15 degrees south), mid (between 15 and 25 degrees south) and southern (between 25 and 35 degrees south). The proportion of swordfish versus tuna catch was calculated based only on reported data.

5. Results

5.1 South Africa

5.1.1 Pelagic longline fishery

South African vessels set a total of 4,063 sets or 5,594,000 hooks between 2000 and 2005 at an annual average of 677 sets or 932,000 hooks per year. Observers recorded seabird by-catch information on 341 sets (lines) or 8% of the total hooks. Japanese, Korean and Philippine vessels set a total of 100 sets (lines) or 279,000 hooks between 2000 and 2005 at an average of 20 sets or 46,500 hooks per year. Observers recorded seabird by-catch data on 34 sets. An average of 978 000 hooks were set per year throughout the fleet, 10% of which carried an observer **(Figure 1a and b)**. Fishing effort concentrated on the continental shelf and extended as far off shore as 1 degree east and 16 degrees north. Observer effort, however, was focused on more inshore trips and along the continental shelf **(Figure 1b)**. Effort was significantly different between years (χ^2=147308, p<0.001, df = 5) and season (χ^2=57333, p<0.001, df = 5) **(Figure 2)**.

There was no significant difference is seabird catch rates between the two fleets (t=0.5, p=0.6) and averaged 0.2 birds per 1000 hooks (2000-2005) and thus kill approximately 196 per year. Albatrosses account for 69% of the birds caught **(Table 1)**. Shy albatrosses were the most commonly caught, followed by black-browed and Atlantic yellow-nosed albatrosses. The remaining 31% was comprised predominantly of white-chinned petrels and cape gannets. The distribution of seabird by-catch in South African longline fisheries is shown by 1 x 1 degree grid squares in **Figure 3**. Catch rates varied between 0.001 and 1.2 birds per 1000 hooks per grid square. Seabird by-catch is the highest in the southeast and along the continental shelf **(Figure 3)**.

Prior to 2005, the use of bird-scaring lines was very low (consistently <10% of the fleet). Since the BirdLife and WWF Responsible Fisheries Programme started making and distributing tori lines in 2005, the use of bird scaring lines improved radically to almost 80% Interviews conducted with compliance officers revealed low enforcement despite a general feeling that these fisheries are impacting seabirds.

5.1.2 Demersal longline fishery

Just over 36 million hooks were set from 2000 to 2004 and effort ranged between 6 million and 13 million hooks annually (average 8.3 million hooks) on 4,276 sets (average 855 per year) between 2000 and 2004 **(Table 4)**. This fishery sets an average of 7,500 hooks per set. A total of 1.3 million hooks (188 sets) were observed, accounting for 4% of total effort during the time period. Effort was significantly different between years (χ^2 = 130879, p<0.001) and season (χ^2=847974, p<0.001) **(Figure 4)**.

There was no seabird by-catch reported in 2000 and 2001. A total of 46 birds were caught at a rate of 0.06 birds per 1000 hooks from 2002 to 2004. Over the entire time period birds were caught at a rate of 0.04 birds per 1000 hooks. 65% of these birds were released alive. White-chinned petrels were the most commonly caught seabird, at a rate of 0.02 birds per 1000 hooks, accounting for 55% of birds caught. Cape gannets were the second most commonly caught (11%) at a catch rate of 0.004 birds per 1000 hooks. Most gannets were released alive. For albatrosses, catch rates were combined because of their low percentage contribution (7%) to the overall seabird by-catch (0.002 albatrosses per 1000 hooks). An extrapolated 301 seabirds are caught by the demersal longline fishery per year **(Table 2)**.

Data werecollected from hake longline trips conducted during 2005 from a total of 116,80 hooks in 27 sets. Four birds were caught: two white-chinned petrels *(Procellaria aequinoctialis)* and two great shearwaters *(Puffinus gravis)* at a mortality rate of 0.02 birds per 1000 hooks. Data used in this study were collected in the spring months when seabird abundance is the lowest and thus may represent a minimum annual estimate.

Despite being a permit requirement, bird-scaring lines permit were seldom used during 2000-2004. According to observer reports, they were flown in only 12% (*n* = 210) of all sets. Many of the fishermen are averse to using bird-scaring lines, citing that they result in gear entanglements and consequently gear loss.

5.2 Namibia

5.2.1 Pelagic longline fishery

Fishing effort data exist for 2002 to 2004 and range between 2.5 and 3.5 million (average 2.9 million) hooks or an average of 1,620 sets per annum **(Figure 5)**. Vessels active in this fishery are typically freezer vessels with a length range between 20 and 55 m (average 28 m) that undertake trips between 30 and 35 days long. Although fishing takes place throughout the year, the main catches for bigeye tuna occur from June to December. Sharks are caught throughout the year. The large pelagic longline fleet operates off the entire coast of Namibia, mostly along the continental shelf, but also in international waters beyond the Namibian EEZ.

By-catch data from Namibian fisheries are poor, but observers report that approximately one bird is killed per 10 day trip, or 0.05 birds per 1000 hooks. Interviews conducted with industry representatives also estimated that pelagic longliners killed approximately one bird every 10 days and reported to be mainly albatrosses (F. Louw, pers. comm.)

A specialized observer collected data from 4 October to 10 November 2004 onboard a large pelagic longline vessel targeting tuna, swordfish and sharks. During the 38 days, 7 seabirds (6 yellow nosed albatrosses and 1 gannet) or 0.6 birds per 1000 hooks were incidentally caught during the process. The line supported between 2,700-3,600 hooks and was 60.4 miles in length. The line was set at approximately 16h00, ending at approximately 24h00 and it was hauled between 06h00 and 16h00. On a second trip conducted between June 9 and June 23, 2006, where 15 sets or 30 770 hooks were observed, three birds were caught (0.1 bird per 1000 hooks), one of which was dead (an adult shy albatross). The two live Atlantic yellow-nosed albatrosses were caught on the haul and released.

The most commonly caught albatrosses are shy, black-browed and Atlantic yellow-nosed albatrosses. Species frequenting the vessel included black-browed, yellow-nosed and shy albatrosses, white-chinned petrels and sub-Antarctic skuas **(Table 3)**.

Since the fishing effort in this fishery is an average 2.9 million hooks per year and the average seabird by-catch rates reported above average 0.07 birds per 1000 hooks, we estimate that approximately 206 birds are caught by this fishery each year.

5.2.2 Demersal longline fishery

Approximately 25 wet fish vessels operate out of both Walvis and Luderitz depending on the availability of fish. This fishery sets, on average, approximately 104 million hooks or 6,040 sets per annum. Effort remained fairly constant over the time period **(Figure 6)**. Note that the data for 2004 are incomplete. The average number of hooks per set increased from 16,500 hooks per set in 2001 to 19,000 hooks per set in 2003. About 80% of all sets are set before sunrise at 06h00. Most of the sets occurred around 04h00 in the morning with hauling activity peaking around midday.

Observers were not required to collect information regarding seabird mortalities. However, of 13 observers interviewed, 12 reported that they felt seabird by-catch was unacceptably high and resulting in population decreases. Estimations of seabird by-catch ranged from none to 10 albatrosses and 20 gannets caught per day and averaged at 7 seabirds per trip.

Six interviews with the industry (skippers, shore skippers and managers) were conducted in Walvis Bay in 2004 and 2006. Results from these interviews revealed an estimate of ± 19 birds (mainly petrels) caught per trip (average of 8 sets per trip). Since an average of 144,000 hooks (18,000 hooks per set X 8 day trip) are set per trip, this equals to an approximate catch rate of 0.13 birds per 1000 hooks. In general, skippers are not aware of the issue and therefore they do not report seabird mortality in their logbooks.

A specialized technician collected data from hake longliners operating out of Luderitz in November 2006. Twenty-one percent or 456,000 hooks were observed. Sixty-three white-chinned petrels were caught at a rate of 0.14 birds per 1000 hooks. Since the total effort in this fishery is on average 104 million hooks per year, we estimate that approximately 14,350 birds are caught by this fishery each year. Sixty of these birds were caught within two days of full moon. The technician also reported numerous cape gannets and a yellow-nosed albatross entangled in fishing gear.

5.3 Angola

Seabird by-catch is likely to occur in coastal artisanal subsistence fishing, semi-industrial vessels and industrial longline fishing. The number of industrial longline vessels ranged between 18 and 25 from 2000 to 2004. Currently, one industrial longliner is fishing for tuna in Angolan waters. Landings of tunas (bigeye, longfin, yellowfin) from artisanal longline operations have increased dramatically from about 14,000 tons is 1999 to between 40,000 and 50,000 tons in 2002 and 2003, respectively.

The accidental capture and mortality of seabirds during the fishing operation are not recorded in these fisheries, which are operated by foreign vessels and use distant ports. No data therefore exist on the by-catch rates of seabirds. Fishing effort averages 3.5 million hooks per annum (ICCAT: 2000 to 2004) in the southern region of Angola (South of 15ºS) where vulnerable seabirds, such as albatrosses and petrels, are more abundant. If seabird catch rates are similar to those in Namibia (0.07 birds per 1000 hooks) then it is estimated that approximately 250 birds may be killed per year in this area.

An attempt was made to gather data by conducting interviews with fishers and these were carried out in January 2005 in the coastal fishing communities of the Namibe Province. One questionnaire was answered completely, 8 incompletely and 21 individuals did not know anything about seabird by-catch. The general response was that seabirds are caught but the number and species vary from trip to trip. Seabirds identified include albatrosses, kelp gulls (*Larus dominicanus*), and black birds likely to be white-chinned petrels or cormorants and cape gannets.

There is an illegal artisanal fishery targeting seabirds, which sets floating lines with approximately 5-7 hooks. This was confirmed by interviewees and observers onboard the *F. Nansen* (September 2002). These vessels target white-chinned petrels and cape gannets for consumption. According to the results of the interviews, they use fish liver as bait. All birds caught were either consumed by crew or sold for 75.00 kz per kg (seventy five kwanzas = US$0.85) resulting in a high demand for seabirds. Most individuals interviewed stated that they were unaware of a seabird fishery for fear of being identified by Port authorities. Seabird fishing activities are popular along the coast of the Namibe Province. The elders of communities report that seabirds and turtles provide most of the protein for their communities in regions where meat is scarce.

During the 2003 and 2004 surveys conducted on the *F. Nansen*, observers reported several cape gannets sighted in southern Angola (particularly around Tombua) entangled in hooks and fishing line.

5.4 Estimated overall impacts

Based on the above analysis, it is likely that approximately 500 birds are killed by South African and Namibian national pelagic longline fleets fishing in the Benguela each year and approximately 14,900 birds are killed by the demersal longline fleets. Based on these estimates, the total impact of these two national fleets is approximately 15,400 birds per year **(Table 4)**. However, these are not the only two nations fishing within the Benguela.

ICCAT effort data for the region reports that nine nations fished within the Benguela from 2000 to 2004 **(Table 5)** setting a total of 172 445 000 hooks or 34 491 000 per year. Chinese Taipei and Japan accounted for 84% of this effort over this time period **(Table 5)**. There was no trend evident between seasons (χ^2=1.7, p=0.2), however there was a significant difference in effort between year (χ^2=3.06, p=0.05) **(Figure 7)**. There was an increase in effort from 2000 to 2003 and then a decrease in 2004.

Based on the South African catch rate of 0.2 birds per 1000hooks and an average annual effort for the southern region of 10.9 million hooks, we estimate that approximately 2,200 birds are caught per annum in this region **(Table 5)**. Similarly for the mid region we base the catch rate on the estimate of 0.07 birds per 1000hooks from the Namibian fishery **(Table 6)**. Effort for this region is approximately 10 million hooks per annum. Therefore, we estimate seabird by-catch to be approximately 700 birds per annum. It is unlikely that albatrosses are caught in substantial numbers North of 15 degrees, although the extent to which petrels (e.g. white-chinned petrels) are caught is unknown. Therefore, we conservatively estimate that approximately 2900 birds are caught by the pelagic longline fishery operating throughout the Benguela per annum **(Table 4)**. Thus total seabird mortality for all longline fleets, i.e. both demersal and pelagic may kill 17,800 birds per year **(Table 4)**.

6. Discussion

This study concludes that three species of albatross (shy, black-browed and Atlantic yellow-nosed), one species of petrel (white-chinned petrel) and the Cape Gannet are caught in levels that raise concerns. Shy albatrosses are the most commonly caught species of albatross in the Benguela region. Shy albatrosses foraging in Southern African waters are most likely from the New Zealand population *steadi* (Abbott *et al*. 2006). The level of mortality reported in this study amounts to approximately 1-5% of this population per year. This species is also impacted by fisheries interactions across much of its foraging and breeding range, with all age classes at risk (Baker *et al*. 2006). However, little is known about their population status, breeding biology, life history and at-sea distribution (Robertson *et al*. 2003). As there are no accurate estimates of population size for this species, there can be no reliable assessments of status or trends (Gales 1998). In the absence of this information, it is not possible to accurately assess whether this level of mortality is sustainable. It is vital that data be collected in order to inform management decisions on how bycatch levels may be affecting this species.

In contrast, accurate population status and trend information is available for black-browed albatrosses feeding in the Benguela, which breed on South Georgia in the southwestern Atlantic. Here population numbers have decreased at a rate of 4.8% per annum since the mid 1970s (Croxall *et al*. 1998). Mortalities occurring in the Benguela current are therefore contributing to this decline and are of grave cause for concern. This species is listed as endangered because it is inferred to be declining at a rate of c.65% over three generations (65 years). Incidental mortality has been identified as the main cause of the observed decline (BirdLife International 2005).

It was not possible to differentiate between Indian and Atlantic yellow-nosed albatrosses in this study with any certainty due to the poor species identification by fisheries observers. Both species are found in the Benguela, but only the Atlantic yellow-nosed albatross is found throughout the region. The Indian yellow-nosed albatross is only found in significant numbers South of Cape Columbine (Sinclair *et al*.2002). The Atlantic yellow-nosed breeds on Gough and all the islands in the Tristan da Cunha archipelago (Cuthbert *et al* 2003). Population modelling predicts that these populations are decreasing at a rate of between 1.5-2.8% on Gough Island and 5.5% on Tristan da Cunha (Cuthbert *et al*. 2003). In the non-breeding season they disperses throughout the South Atlantic Ocean, mainly between 45°S to 15°S, and has been recorded off the coast of Argentina, Brazil and the west coast of southern Africa (Harrison 1983). This species is listed as endangered owing to its very small breeding range, and rates of decline at two long-term study colonies, which indicate an 58% overall population reduction over three generations (72 years) (BirdLife International 2005). However, population models suggest that this decline rate may be an underestimate. It was estimated that at least 900 birds per annum are killed off the coast of south-eastern Brazil, where it is known to be one of the commonest species attending longline boats (Olmos *et al*. 2000). Mortality occurring in the Benguela is thus of concern.

Indian yellow-nosed albatrosses occurring in the Benguela breed on Prince Edward Island, Crozet Islands, Kerguelen Islands, Amsterdam and St Paul Islands. The population breeding on Marion Island appears to be stable, but decreasing at Amsterdam Island, the main breeding site (Weimerskirch and Jouventin 1998). Outside the breeding season, it disperses throughout the Indian Ocean and is frequently observed off south-western Australia, the Tasman Sea and northeastern New Zealand (Harrison 1983). In addition to indian yellow-nosed albatrosses being caught by longliners operating in the Benguela they are also caught off south-western Australia (600 may be killed annually) (Gales 1998, Weimerskirch and Jouventin 1998), by tuna longliners in subtropical

waters (Weimerskirch and Jouventin 1998), and patagonian toothfish *(Dissostichus eleginoides)* longliners in the vicinity of the Prince Edward Islands (Ryan and Boix-Hinzen 1999). This species is considered Endangered on the basis of an estimated overall decline of 63% over three generations (71 years), based on data from the population on Amsterdam Island. This observed decline is the result of adult mortality and poor recruitment owing to interactions with fisheries and disease (Weimerskirch 2004).

The most common petrel species killed by fishing operations in the Benguela is the White-chinned petrel, which is classified as Vulnerable (BirdLife International 2005). This species breeds throughout the sub-Antarctic and disperses widely during its non-breeding season. As a result they are killed by many fisheries throughout its range (Olmos 1997, CCAMLR 1997, CCAMLR 1998, Gales *et al.* 1998, Taylor *in litt.* 1999). Although no reliable historical population estimates exist for this species, partly because they nest in burrows and thus present a challenge to accurately assess, the few monitoring studies that exist detect a decline. Given the high longline mortality recorded in recent years, substantial population decrease are inevitable (Birdlife International 2005).

The cape gannet population averaged 250,000 pairs (1956 to 1969) and decreased to 150,000 pairs (1979 to 2006) (Crawford *et al.* in press). Decreases were especially high in Namibian colonies which decreased by 85-98% from 1956 to 2006. Although the decreasing numbers of cape gannets have been attributed to a declining sardine stock, the extent to which mortality as a result of fisheries interactions may be contributing is unknown (Cordes 1996, Crawford *et al.* in press). Six-hundred fishing hooks were found in the gannet colony on Ichaboe Island after three years of guano accumulation (Tony Williams unpublished data). Furthermore, anecdotal sightings of birds entangled in fishing gear have been frequently reported from Namibia. This reports highlights that it could be significant and warrants further investigation. Artisanal fishers catching cape gannets and white-chinned petrels by means of floating handlines for consumption in Angola is also a cause for concern as both these species are also vulnerable to longline fishing mortality as detailed above.

A similar suite of seabirds are not only caught by longline fisheries in the Benguela, but also by trawl operations. Based on conservative estimates approximately 18 000 birds are killed per year by the South African demersal trawl fishery. Of the birds killed, 39% were shy albatrosses, 29% black-browed albatrosses, 14% cape gannets and 9% white-chinned petrels. The cumulative mortality of multiple fisheries is likely to be further impacting these already vulnerable species.

Fisheries information on non-target species is frequently poorly collected, recorded and maintained. This is especially true in developing countries. (Barker and Schluessel 2005). The three coastal state countries bordering the Benguela current (South Africa, Namibia and Angola) are no exception. South Africa has an effective observer programme which has been collecting data on fishing operations, including by-catch, since 2000. As a result the most reliable and comprehensive data for the region comes from this programme. However, since seabird abundance and species composition are not uniform throughout the region (Crawford *et al.* 1991), catch rates from South Africa cannot simply be used to extrapolate for the entire region. There is a decrease in the abundance of albatrosses in a northerly direction and species composition changes from mostly shy and black-browed albatrosses dominating in the south to an increase in the relative proportion of Atlantic yellow-nosed albatrosses in the northern Benguela (Crawford *et al.* 1991). However, since the shy albatross is the most aggressive and will, in general, out-compete black-browed and yellow-nosed albatrosses, shy albatrosses make up a larger proportion of the catch independent of their relatively low abundance (Crawford *et al.* 1991). The decreasing catch rate from 0.2 birds per 1000 hooks in the South African pelagic longline fishery to 0.07 birds per 1000 hooks in the Namibian pelagic longline fishery supports a decrease in abundance of seabirds in a northerly direction. Since the seabird abundance (especially albatross abundance) is likely to decrease further as we cross the border in Angola, it may be that a simple extrapolation from the Namibian fishery is not appropriate. However, no seabird bycatch data is available for that area. The same northerly decreasing trend is not observed for the demersal longline fishery which increased from 0.04 birds per 1000 hooks in the South African fishery to 0.14 birds per 1000 hooks in the Namibian fishery. A higher catch rate is supported by interviews conducted with skippers and observers and may be the result of gear differences between the two fleets. The South African fishery typically set 7,500 hooks per set whereas the Namibian fishery set approximately 19 000 hooks per set increasing the effort substantially and therefore increasing the likelihood of catch a bird per set. As target catch CPUE decreases it is possible that effort may increase and further exacerbate seabird bycatch in Namibian waters. A further consideration is the weighting regime which in the South African fishery is an average of 6 kg weights spaced at 100 m interval along the line as opposed to 3 kg weights with only the occasional heavier weight placed in between in the Namibian Fishery. The consequence of this combination is that the gear is likely to sink substantially slower and thus be available to the birds for longer.

Seabird catch rates reported in this study for the South African west coast are lower than previous estimates for South Africa as a whole and this is likely to be due to the exclusion of the Agulhas Bank where large concentrations of albatrosses and petrels are found (Ryan *et al.* 2002). Seabird bycatch in the pelagic fishery was estimated at 0.8 birds per 1000 hooks (Ryan *et al.* 2002) during 1998-2000 when primarily Asian vessels operating on the western Agulhas Bank. Ryan *et al.* (2002) estimated that this fishery killed between 19 000 and 30 000 seabirds annually. Barnes *et al.* (1997) reported that the South African demersal longline industry killed approximately 8000 white-chinned petrels (0.4 birds per 1000 hooks set) annually. Both these studies included data collected on the Agulhas Bank.

Catch rates reported in this study are higher than the international standard of 0.05 birds per 1000 hooks. This is unacceptable in light of the development of effective and relatively inexpensive methods of reducing this mortality (Alexander *et al.* 1997, FAO 1999, Melvin *et al.* 2004). In order to address this we recommend the following:

1. Data collection: More information is urgently required. Priority areas include baseline information for Namibia and Angola. There is also a further need to conduct more interviews with artisanal fishers and coastal communities in order to understand and reduce the level of by-catch and intentional catch of threatened seabird species in these areas.
2. Conduct mitigation trials: There is a need to conduct line sink rate and bird-scaring line trials in Namibia and continue trials underway in South Africa.
3. Implementation of known mitigation into permit conditions.
4. Education and awareness: target groups should include fishers, fisheries observers, compliance staff and fisheries managers. Furthermore, general education and awareness on the plight of these species can be extended into coastal communities.
5. Incentives to comply should be developed (market and regulatory).
6. The relevant agreements should be ratified (e.g. ACAP) and recommendations implemented (e.g. development of a NPOA-seabirds).
7. Implement ICCAT's seabird resolution.

In conclusion, seabird by-catch is substantial in the Benguela Current Large Marine Ecosystem and requires the commitment of all to resolve this matter. This paper has highlighted the paucity of information available for the region. Although this needs to be addressed we do provide sufficient information to encourage the immediate implementation of mitigation measures such as the use of bird-scaring lines for all longline fisheries operating within the region.

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Table 1. Seabird by-catch rates for the pelagic longine fishery and species composition, 2000 to 2005.

	Species	*By-catch rate (birds per 1000 hooks)*	*Estimated annual catch*	*%*
Shy albatross	*Thalassarche cauta*	0.07	76	39%
Black-browed albatross	*Thalassarche melanophrys*	0.04	39	20%
Yellow-nosed albatrosses	*Thalassarche chlororhynchos per carteri*	0.02	20	10%
Other albatrosses		0.01	18	9%
White-chinned petrel	*Procellaria aequinoctialis*	0.02	20	10%
Other petrels		0.02	24	12%
Cape gannet	*Morus capensis*	0	0	0%
Total		**0.2**	**196**	**100%**

Table 2. Seabird by-catch rates for the demersal longine fishery and species composition, 2000 to 2005.

	Species	*Catch rate birds per 1000 hooks*	*Estimated Annual catch*	*%*
Shy albatross	*Thalassarche cauta*	Unknown	-	-
Black-browed albatrosses	*Thalassarche melanophrys*	Unknown	-	-
Yellow-nosed albatrosses	*Thalassarche chlororhynchos per carteri*	0.0015	12	4%
Other albatrosses		0.0008	7	3%
White-chinned petrel	*Procellaria aequinoctialis*	0.02	166	55%
Other petrels		0.01	83	27%
Cape gannet	*Morus capensis*	0.004	33	11%
Total		**0.04**	**301**	**100%**

Table 3. Average daily numbers of seabirds frequenting a pelagic longliner fishing off Namibia in June 2006.

Species	Species name	North of 25°	South of 25°
Shy albatross adult	*Thalassarche cauta*	1	3
Shy albatross sub-adult	*Thalassarche cauta*	0	2
Black-browed albatross adult	*Thalassarche melanophris*	3	12
Black-browed albatross sub-adult	*Thalassarche melanophris*	2	4
Yellow-nosed albatross adult	*Thalassarche chlororhynchos*	11	10
Yellow-nosed albatross sub-adult	*Thalassarche chlororhynchos*	2	2
Wandering per royal albatross	*Diomedea exulans per Diomedea epomophora*	1	2
White-chinned petrel	*Procellaria aequinoctialis*	7	10
Sub-antarctic skua	*Catharacta antarctica*	1	3

Table 4. Seabird by-catch per fishery and per country.

Species	Seabird by-catch per longline fishery sector (confidence rating)					Minimum per annum**		IUCN category		Status
	SA plagic (high)	SA demersal (high)	Nam pelagic (medium)	Nam demersal (medium)	Angolan pelagic (poor)	Angolan artisanal handline (poor)				
Shy albatrosses	0.07	recorded	recorded	recorded	Possible, but likely to be rare	Possible, but likely to be rare	>900		Near Threatened	Unknown
Black-browed albatrosses	0.03	recorded	recorded	recorded	Possible, but likely to be rare	Possible, but likely to be rare	>60		Endangered	Decreasing
Atlantic yellow-nosed albatrosses	0.02	0.0015	recorded	recorded	likely	Likely	>200		Endangered	Decreasing
Other albatross	0.01	0.0008					>200			
Total albatrosses	0.13	0.002					>1300			
White chinned petrel	0.02	0.02	recorded	0.3	likely	recorded	>15 000		Vulnerable	Decreasing
Other petrels	0.02	0.01					>600			
Total petrel	0.04	0.03					>15 600			
Cape gannet	0	0.004	recorded	recorded	likely	recorded	>30*		Vulnerable	Decreasing
Seabird Total	0.2	0.04	0.07	0.3	unknown	unknown	>17 800			

* Underestimated due to lack of information.
**This reflects only estimates for countries where we have a catch rate.

Table 5. Proportion of effort between nations fishing in the Benguela.

Flag	No. of hooks	%
Chinese Taipei	75, 378,000	46.4%
Japan	60,714,000	37.4%
Portugal	7,648,000	4.7%
Spain	6,549,000	4.0%
People's Republic of China	5,948,000	3.7%
Namibia	3,423,000	2.1%
South Africa	1,664,000	1.0%
Republic of Korea	906,000	0.6%
Belize (foreign obs.)	173,000	0.1%

Table 6. Total and annual average effort for northern, mid and southern Benguela.

Region	Total hooks	Annual average	%	Catch rate	Total birds
Northern	67,570,000	13,514,000	39%	Unknown	Unknown
Mid	49,960,000	9,993,000	29%	0.07	700
Southern	54,909,000	10,984,000	32%	0.2	2,200
Total	**172,445,000**	**34,491.000**	**100%**		**>2,900**

(a)

(b)
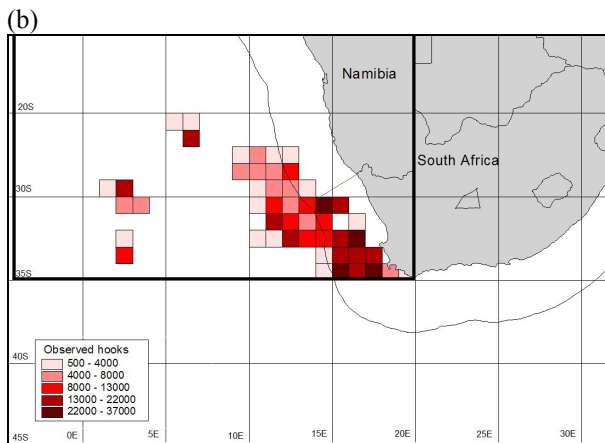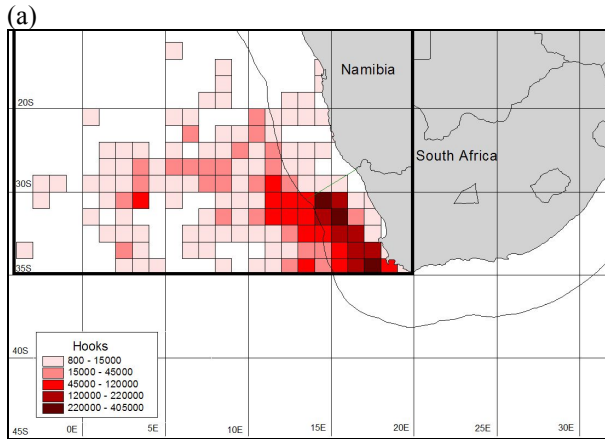
Figure 1. (a) Total and (b) observed effort for the pelagic longline fishery (BCLME border is bolded).
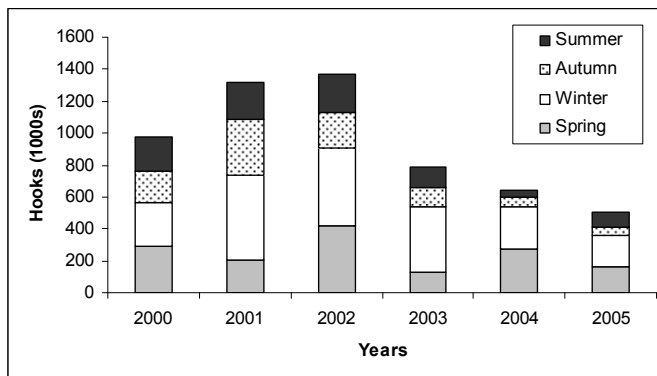
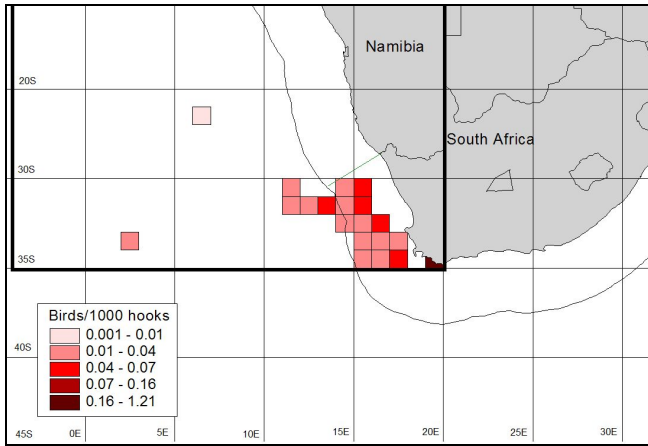**Figure 2.** Fishing effort in the pelagic longline fishery per year and season.

Figure 3. Distribution of seabird by-catch according to observer data (South African and Asian flagged), 2000 to 2005.
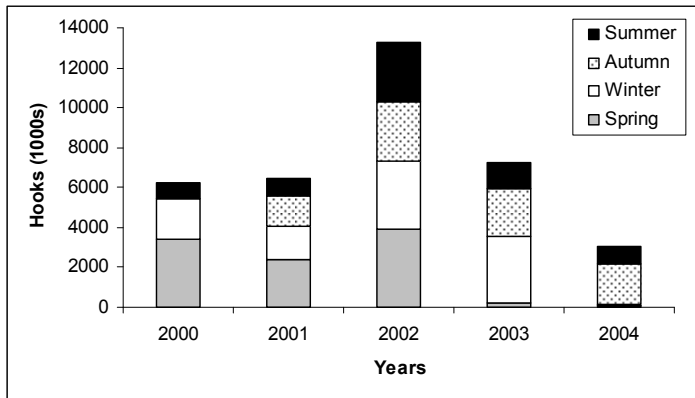

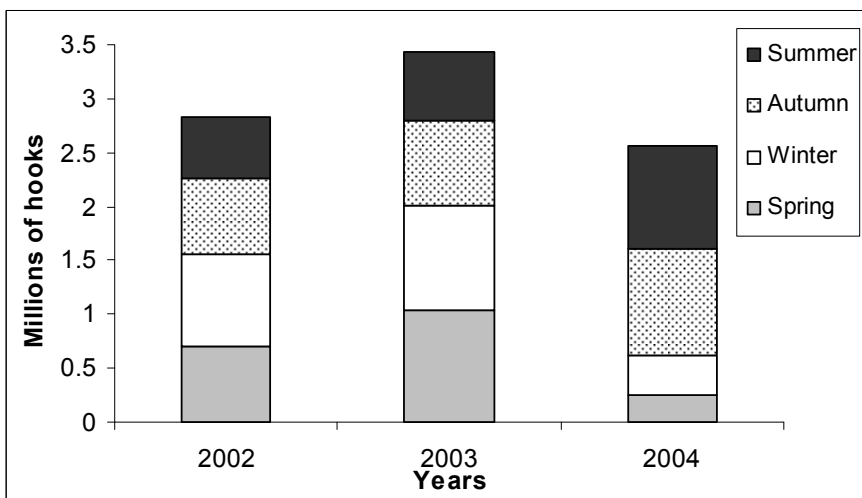**Figure 4.** Fishing effort in the pelagic longline fishery per year and season.

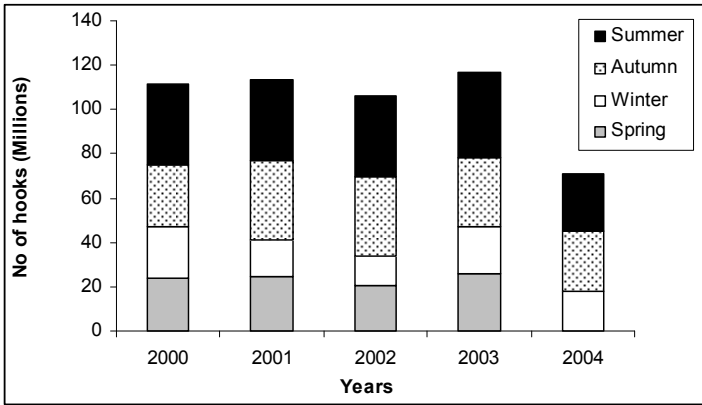**Figure 5.** Number of hooks and sets per season and year set by Namibian pelagic longline vessels, 2002 to 2004.

Figure 6. Number of hooks set per season and year by Namibian demersal longline vessels, 2000 to 2004.
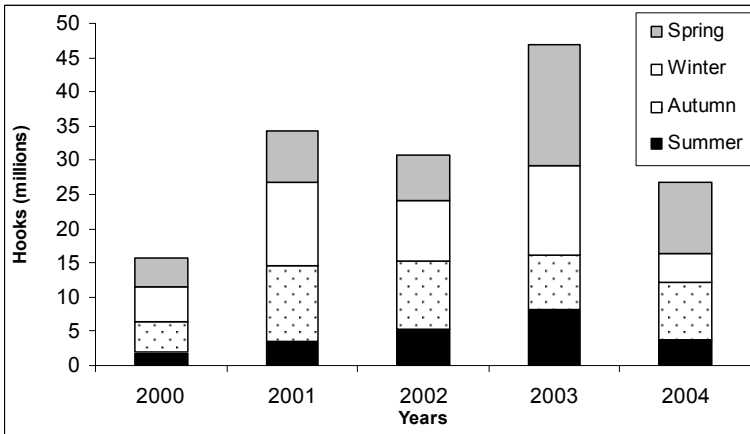

Figure 7. Seasonal and annual trends in effort data for the Benguela region (based on ICCAT data).