TOWARDS AN ECOSYSTEM APPROACH TO LONGLINE FISHERIES IN THE BENGUELA:

An assessment of impacts on seabirds, sea turtles and sharks

Samantha Petersen, Deon Nel and Aaniyah Omardien (Editors)

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Towards an Ecosystem Approach to Longline Fisheries in the Benguela:

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FOREWORD

Marine science and fisheries management in the coastal countries of the Benguela ecosystem have a long and proud history, recognised throughout the world for innovative and proactive approaches. This work was substantially boosted and strengthened when the Benguela Current Large Marine Ecosystem Programme started in 2002 and it has supported and facilitated a wealth of high-level studies and activities central to the needs of responsible management of human uses of and impacts on this productive and rich ecosystem.

One of the strongest features of southern African marine science has always been its emphasis on ecosystem interactions, as manifested in the Benguela Ecology Programme, the Benguela Environment Fisheries Interaction and Training Programme (BENEFIT) and the BCLME Programme. The need for an ecosystem view in management of fisheries is nothing new and those intimately connected with fish and fishing have always understood the importance of the wider ecosystem to the health and dynamics of fish stocks. However, as entertainingly described by Peter Larkin in his far-sighted epitaph to the concept of maximum sustainable yield,[1] the 20th Century world of fisheries management got caught-up in hopes and expectations arising from population dynamics theory and modelling. In the excitement we temporarily lost sight of the broader picture. For responsible fisheries, it is important to understand the dynamics of individual populations, as far as practically possible, and take them into account in management, but the fact that this is a necessary but not a sufficient condition is now being re-discovered.

The re-awakening to the need to manage fisheries within the context of their ecosystem has been taking place for more than a decade, perhaps stimulated most strongly by the 1992 Conference on Environment and Development (UNCED). The principle is now recognised and promoted by many international, national and non-governmental organizations and institutions. Within the global fisheries community, the need for an ecosystem approach to fisheries (EAF) was formally recognised in the 2001 Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem and reinforced by the WSSD Plan of Implementation in 2002, which encourages States to implement EAF by 2010. The Food and Agriculture Organization of the United Nations (FAO), working from the base of the Code of Conduct for Responsible Fisheries, has been one of the organizations working strongly to assist countries and regional fishery organizations in their attempts to achieve this goal. In the view of FAO, the need to "plan, develop and manage fisheries in a manner that addresses the multiple needs and desires of societies, without jeopardizing the options for future generations..." is a central foundation of EAF[2]. Meeting this need is a difficult but essential goal for the future of our world.

[1] Larkin, P.A. 1977. An epitaph for the concept of maximum sustainable yield. *Trans.Am.Fish.Soc.* ***105**:1-11.*

[2] FAO. 2003. The ecosystem approach to fisheries. *FAO Technical Guidelines for Responsible Fisheries* **4** Suppl. 2. Rome, FAO. 112pp.

With this background, I was pleased and honoured to be asked to write the foreword to this volume of five high-quality and very relevant papers on a key aspect of EAF, the impact of fisheries on the ecosystem. In particular, these papers address the impacts on a range of species of conservation concern, including a number of very serious concern. Notwithstanding the history of ecosystem research, this topic has frequently been neglected in the past, and data and information were not always easy to come by. The authors of the papers have gone to great lengths to identify and use the best information available in order to arrive at what, to my knowledge, are the first region wide estimates of the impact of different fisheries on seabirds, sharks and turtles. The results and recommendations made in these papers therefore represent essential information for the three countries, and for the newly established Benguela Current Commission, as they progress in their determination to implement an ecosystem approach across the region.

Within the context of EAF, these studies, initiated and led by WWF South Africa and Birdlife International, are particularly significant because of their recognition of and attempts to address the "multiple needs and desires of society". Underpinned by an urgent concern for the status of the species being impacted, the authors have endeavoured to consider and recommend solutions that recognise the social and economic importance of the fisheries. They similarly place strong emphasis on the need for stakeholder consultation and participation in the search for difficult but urgent solutions. The studies themselves have made an important start in this process and have involved talking to and working with fishers ranging in scale from artisanal fishers in Angola to large, commercial fishing companies, as well as the management agencies in the three countries. A wonderful example of an attempt to find optimal solutions is referred to in the paper by Petersen, Honig and Nel. They mention a project within the BirdLife and WWF Responsible Fisheries Programme, conducted together with the Kommetjie Environmental Action Group of South Africa, in which residents of a Kommetjie home for the disabled are assembling tori (bird-scaring) lines for use in local long-line fisheries. To date, over 100 tori lines have been made and distributed to fishing vessels. Innovative solutions such as this one will have a vital role to play as the BCLME countries strive to reconcile the urgent needs of sustainable use, conservation and poverty reduction.

This volume of papers is to be welcomed as a fundamental and important contribution to the realisation of the goals of the WSSD in relation to EAF.

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CONTENTS

1. INTRODUCTION

Over the past decade there has been global concern regarding the bycatch of seabirds, sea turtles and sharks in fishing operations (Croxall and Gales 1998, Chaloupka and Limpus 2001, Watson 2003, Coelho *et al.* 2003, Lewison *et al.* 2004, BirdLife International 2005, Megalofonou *et al.* 2005). The incidental mortality of these species due to longline fisheries has been widely held responsible for the declining populations and threatened conservation status of several species (Lewison *et al*. 2004, BirdLife International 2005, Sant & Lack 2006).

For seabirds and to a lesser extent for sea turtles, effective and relatively inexpensive methods of reducing the number of animals killed in these fishing operations have been developed (Brothers *et al*. 1999, FAO 1999, Melvin & Robertson 2001, Watson 2003). Although effective solutions to reduce shark bycatch have not yet been identified we are equally concerned about their capture, given their vulnerable life history characteristics. Furthermore, governments of many nations and several international organizations (e.g. Food and Agricultural Organisation (FAO)) have demonstrated strong resolve to reduce these unnecessary deaths (FAO 1999). Despite this, accurate information and assessment of the scale of the threat and the use of known mitigation measures is still low in many fisheries.

The Benguela Current Large Marine Ecosystem (BCLME) is one of the most productive systems in our global oceans and attracts millions of top predators such as seabirds, sea turtles and sharks. Many of these species travel thousands of kilometers, sometimes across entire oceans, to feed in its nutrient rich waters (BirdLife International 2004). Not surprisingly, the BCLME is also a focus of large commercial fishing operations within the Exclusive Economic Zones (EEZs) of South Africa, Namibia and Angola, as well as on the high seas. The spatial overlap of large numbers of top predators and large commercial fisheries in a confined area has the potential of unsustainable catch levels of many of these threatened species.

This situation prompted the WWF Responsible Fisheries Programme in partnership with the BirdLife Marine Programme and the Benguela Current Large Marine Ecosystem (BCLME) Programme, to embark on a project aimed at reducing the bycatch of seabirds, sea turtles and sharks in the region. The project was built around three major objectives:

1. To conduct an assessment of the scale and nature of the mortality of seabirds, sea turtles and sharks in longline fishing operations in the BCLME.
2. To conduct sea trials of technical measures for reducing the bycatch of these species.

3. To raise the level of awareness and facilitate continued collaboration with the fishing industry.

Although, this report mainly synthesizes the findings of the assessment component of the project, it should be noted that major successes have been achieved under all three objectives. At-sea trials of mitigation measures have resulted in the technical refinement of bird-scaring lines, and an improved understanding of line sink rates. These findings have resulted in the modification of fishing permit conditions in the South African longline fisheries. The project has also been very successful in raising the level of awareness within the fishing industry, fisheries observers and compliance officers. Several multi-stakeholder meetings have been held with the different longline fisheries in both South Africa and Namibia. These have generated very constructive dialogue on the practical issues surrounding the development of mitigation measures. These meetings have been characterized by commitment from the industry to become involved in finding solutions.

The progress of this project as described in this report should also be seen in the light of a global move from single species fisheries management towards an Ecosystem Approach to Fisheries (EAF) management. An EAF recognises the need to adopt a holistic ecological approach which considers impacts on both the target and non-target species, as well as direct or indirect ecosystem effects of fishing operations (Cochrane *et al*. 2004, Shannon *et al*. 2004). Only by maintaining the integrity of the ecosystem can we ensure the sustainability of our fisheries and the survival of our vulnerable marine life. Separate to this project, the three nations of the Benguela region were also engaged in a project, under the leadership of the BCLME and FAO, to assess the feasibility of implementing an EAF in the region. All three countries have committed, under the World Summit on Sustainable Development (WSSD) (UN 2002), to implementing an EAF by 2010.

It is hoped that the findings and recommendations of this report, not only provide a platform for reducing the wasteful killing of these vulnerable species in longline fishing operations but that this report also provides an important stepping stone for the implementation of a comprehensive EAF in the Benguela Current Large Marine Ecosystem.

REFERENCES

BIRDLIFE INTERNATIONAL 2004 – *Tracking ocean wanderers: the global distribution of albatrosses and petrels. Results from the Global Procellariiform Tracking Workshop, 1–5 September, 2003, Gordon's Bay, South Africa.* Cambridge, UK: BirdLife International.

BIRDLIFE INTERNATIONAL 2005 – In: IUCN 2006. *2006 IUCN Red List of Threatened Species*. www.iucnredlist.org.

BROTHERS, N.P., COOPER, J. and S. LOKKENBORG. 1999 – The incidental catch of seabirds by longline fisheries: worldwide review and technical guidelines for mitigation. FAO *Fish. Circ*. **937**: 1-100.

CHALOUPKA, M. and C. LIMPUS 2001 – Trends in the abundance of sea sea turtles resident in southern Great Barrier Reef waters *Biological Conservation*. **102**: 235-249

COCHRANE, K.L., AUGUSTYN, C.J., COCKCROFT, A.C., DAVID, J.H.M., GRIFFITHS, M.H., GROENEVELD, J.C., LIPINSKI, M.R., SMALE, M.J., SMITH, C.D. and R.J.Q. TARR 2004 – An ecosystem approach to fisheries in the southern Benguela context. Ecosystem Approaches to Fisheries in the Southern Benguela. *African Journal of Marine Science*. **26**: 9-35.

COELHO, R., BENTES, L., GONCALVES, J.M.S., LINO, P.G., RIBEIRO, J. and K. ERZINI 2003 – Reduction of elasmobrach by-catch in the hake semipelagic near-bottom longline fishery in the Algarve (Southern Portugal). *Fisheries Science.* **69**: 293-299

CROXALL, J.P. and R. GALES 1998 – An assessment of the conservation albatrosses. In: Robertson G and R Gales (eds). *Albatrosses biology and conservation.* Chipping Norton: Surrey Beatty and Sons. pp 46-65

FAO. 1999 – Indicators for sustainable development of marine capture fisheries', FAO Technical Guidelines for Responsible Fisheries No. 8, FAO, Rome. Available at www.fao.org

LACK, M. and G. SANT 2006 – Confronting Shark Conservation Head On! TRAFFIC International, Cambridge, UK

LEWISON RL, FREEMAN SL and L.B. CROWDER 2004 – Quantifying the effects of fisheries on threatened species: the impacts of pelagic longlines on loggerhead and leatherback sea sea turtles. *Ecology letters.* **7**: 221-231

MEGALOFONOU, P., DAMALAS, D. and C. YANNAPOULOS 2005 – Composition and abundance of pelagic shark by-catch in the eastern Mediterranean Sea. *Cybium*. **29**: 1350-140

MELVIN, E.F. and G.R. ROBERTSON. 2001– Seabird mitigation research in longline fi sheries: status and priorities for future research and actions. *Mar. Ornithol.* **28**: 178–181.

SHANNON, L.J., COCHRANE, K.L., MOLONEY, C.L. and P. FREON 2004 – Ecosystem approach to fisheries management in the Southern Benguela: A workshop review. Ecosystem Approaches to Fisheries in the Southern Benguela. *African Journal of Marine Science.* **26**: 1-8

WATSON, J.W., FOSTER, D.G., EPPERLY, S. and A. SHAH 2003 – Experiments in the Western Atlantic Northeast distant waters to evaluate sea sea turtle mitigation measures in the pelagic longline fishery. U.S. Department of Commerce National Oceanic and Atmospheric Administration NOAA Fisheries http://www.mslabs.noaa.gov/mslabs/docs/pubs.html

2. KEY FINDINGS

2.1 Seabirds

An estimated 33 850 seabirds are killed by pelagic and demersal longline fleets operating in the BCLME per annum.

- South African longline fisheries are estimated to kill approximately 500 birds per annum (200 by the pelagic longline fishery and 300 by the demersal longline fishery).
    - Although regulations are in place, compliance levels are low.
- Namibian longline fisheries are estimated to kill approximately 30 850 birds per annum (200 by the pelagic longine fishery and 30 650 by the demersal longline fishery).
    - No regulations are in place.
- Gannets and White-chinned Petrels are illegally killed for consumption by artisanal longline fisheries in southern Angola.
- All pelagic longline fleets operating on the high seas are estimated to kill approximately 2 900 birds per annum.

2.2 Sea turtles

An estimated 4 200 sea turtles are caught by pelagic longline fleets operating in the southern and central regions of the BCLME (i.e. south of 15 ° south) per annum.

- The South African pelagic longline fishery targeting tuna and swordfish is estimated to catch approximately 200 sea turtles per annum.
    - The critically endangered leatherback sea turtle and the endangered loggerhead sea turtle comprise 16% and 60% respectively.
- The Namibian pelagic longline fishery targeting tuna, swordfish and sharks is estimated to catch approximately 700 sea turtles per annum.
- Catches are likely to be the highest in the northern Benguela, where sea turtle abundance and fishing (longline and artisanal) activity is the highest however no sea turtle bycatch data exists for these fisheries.
- In Angola, sea turtles are caught by artisanal fisheries for consumption.
- No mitigation measures are in place throughout the BCLME region.

"South Africa" refers to all vessels operating with the EEZ to 20 degrees east as well as South African flagged vessels operating on the high seas i.e. the impact of all vessels operating under South Africa's jurisdiction, similarly for Namibia and Angola

2.3 Sharks

We estimate that approximately 6.6 million pelagic sharks are caught by all pelagic longline fleets operating in the BCLME per annum. Two species dominate this catch, namely blue (approximately 5.5 million per annum) and the vulnerable short-fin mako (1.1 million per annum) sharks.

- The South African pelagic longline fishery targeting tuna and swordfish is estimated to catch approximately 22 000 pelagic sharks per annum.
  - Blue and mako sharks comprise 84% and 10% respectively.
- The Namibian pelagic longline fishery targeting tuna, swordfish and sharks is likely to catch approximately 250 000 pelagic sharks per annum.
  - Blue and mako sharks comprise 51% and 8% respectively.

In many cases catch rates increased over time due to an increase in demand for shark products such as shark fins for the Asian market.

We estimate that approximately 1.5 million demersal sharks and skates are killed in demersal longline fisheries targeting hake in South Africa and Namibia per annum.

Approximately 400 000 sharks and skates are killed by the South African demersal longline fishery.

Approximately 1 million sharks and skates are killed by the Namibian demersal longline fishery.

These are minimum estimates as they only pertain to retained catch.

3. RECOMMENDATIONS

3.1 Regional

1. International Convention for the Conservation of Atlantic Tunas (ICCAT)
    - This report highlights the lead South Africa, Namibia and Angola should take in the process of bycatch assessment by collecting and submitting data.
    - To address seabird bycatch the use of "*tori*" or bird-scaring lines should be mandatory for all longline vessels operating within the BCLME.
    - Existing data should be used to evaluate the health of blue and mako shark populations within the BCLME.
    - Fishers should be encouraged and trained to release live sea turtles caught as a minimum mitigation measure. Further measures should be investigated.
2. Memorandum of Understanding concerning Conservation Measures for Marine turtles of the Atlantic Coast of Africa
    - This report highlights the need to develop conservation measures for at-sea threats to sea turtles in the Atlantic.
3. Interim Benguela Current Commission (IBCC)
    - This report highlights the need to harmonise management procedures and regulations pertaining to the capture of seabirds, sea turtles and sharks throughout the BCLME.

3.2 South Africa

1. Low compliance to current permit conditions exists. This could be improved by implementing the following:
    - Increase education and awareness of fishers, compliance officers, fisheries managers and fisheries observers.
    - Increase enforcement of permit conditions.
    - Encourage voluntary compliance.
2. The following research needs were identified:
    - For seabird bycatch the highest priority is to complete line sink rate trials for pelagic and demersal longline fisheries.

- For sea turtle bycatch,further investigation of mitigation measures is required.
- For shark bycatch there is a need to further investigate mitigation measures.

3. The following policy needs were identified:
   - There is an urgent need to finalise and adopt the National Plan of Action for reducing the incidental catch of seabirds in longline fisheries (NPOA-seabirds).
   - There is an urgent need to finalise the National Plan of Action for the conservation and management of sharks (NPOA-sharks).
   - The sea turtle policy should be finalised and adopted.
4. The following management needs were identified:
   - There is a need to establish multi-stakeholder working groups under the Resource Management Working Groups (RMWG) which can deal with specialised technical issues such as those pertaining to bycatch.
   - A Total Allowable Catch (TAC) should be set for the main shark species.
   - South Africa should implement ICCAT seabird, sea turtle and shark resolutions.

3.3 Namibia

1. The following research needs were identified:
   - There is a need to collect more data in order to refine the assessment of seabird, sea turtle and shark bycatch in Namibian waters.
   - Specialised observers should be trained to collect bycatch data.
2. The following policy needs were identified:
   - There is an urgent need to finalise and adpot the NPOA-seabirds.
   - We recommend that the Agreement for the Conservation of Albatrosses and Petrels (ACAP) is ratified.
3. The following management needs were identified:
   - Seabird mitigation measures, such as the use of bird-scaring lines, should be included in permit conditions and enforced.
   - A TAC should be set for the main shark species.

- There is a need to improve the education and awareness of fishers, compliance officers, fisheries managers and fisheries observers.
- Namibia should implement ICCAT seabird, sea turtle and shark resolutions.

3.4 Angola

1. The following research needs were identified:
   - Since no bycatch data in longline fisheries exist, there is a need to collect this information in order to conduct an accurate assessment of seabird, sea turtle, pelagic and demersal shark bycatch in Angolan waters.
   - Further surveys and interviews in coastal communities should be conducted.
   - An effective observer programme should be implemented.
2. The following policy needs were identified:
   - Develop and implement a NPOA-seabirds and NPOA-sharks.
   - Implement FAO sea turtle bycatch guidelines.
3. The following management needs were identified:
   - Improve food security for coastal communities and develop alternative sustainable livelihoods.
   - Compliance of illegal capture of seabirds and sea turtles should be addressed.
   - A TAC should be set for the main shark species.
   - Improve education and awareness of coastal communities, fishers, compliance officers, fisheries managers and fisheries observers.
   - Angola should implement ICCAT seabird, sea turtle and shark resolutions.

SEABIRDS

The impact of longline fisheries on seabirds in the Benguela Current Large Marine Ecosystem

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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 bycatch in the Benguela Current Large Marine Ecosystem. Bycatch rates for South African fisheries were 0.2 and 0.04 birds per 1 000 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 birds per 1 000 hooks in the pelagic longline fishery and 0.3 birds per 1 000 hooks in the demersal longline fishery. Together Namibian longline fisheries are likely to kill approximately 30 850 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 Cape 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 from ICCAT which averaged at 34.5 million hooks per year. This fishery is likely to be killing approximately 2 900 birds per year. Thus a total of 33 850 birds are estimated to be killed per year by longline fisheries operating throughout the region.

Key words: *seabird bycatch, pelagic and demersal longline fishing*

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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 on by fishing operations (Ryan and Rose 1995).

Occurrence of seabird 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 Albatross *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 16^{o}S, 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 16^{o} S 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 14°30 S, 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 11°10 S and 11°15 S (the northwestern edge of the Quicombo bank).

Cape Gannets proved to be the most abundant seabird with high numbers occurring between 11° S and 12° S and south of 16° S. About 1 600 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).

Longline fisheries operating in the Benguela

There are currently two longline fisheries operating within the Benguela Current Large Marine Ecosystem (BCLME): 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).

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*, Southern 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.

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 hake *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).

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 tuna, swordfish, blue and mako sharks (Voges 2005).

Namibian demersal longline fishery

The 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 tonnes for the past few years.

Angolan line fisheries

There are three fisheries in Angola where seabird mortality is likely to occur namely in coastal artisanal subsistence fishing (vessels smaller than 10 m) targeting line fish such a groupers (*Epinephelinae*), 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 tonnes per day and approximately 240 days per year), and handline (mainly used by artisanal fishers) and commercial longlines (Duarte 2005).

Although bycatch 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 of longline fisheries on seabirds foraging within the 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 the International Convention for the Conservation of Atlantic Tunas (ICCAT). Management and research recommendations are made, based on this information.

2. Methods

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

At-sea collection of data

Data was collected by fisheries' observers in South Africa from 2000 till 2005. This information included seabird bycatch 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 is available from Namibia and Angola.

A specialised observer collected seabird bycatch 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 of 2005. Data for the swordfish longline fishery, was 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 during June of 2006.

Levels of bycatch (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 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 = Region

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

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 bycatch in the artisanal fisheries. A field guide was used to aid the identification of the seabirds caught.

Effort data

To characterise pelagic longline effort within the BCLME 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 from 2000 to 2004. Some manipulation and interpretation of the data was 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 was reported by 5 X 5 degree grid square. For extrapolating a total seabird mortality for the BCLME the effort is divided into three regions namely northern (between 5 and 15° S), mid (between 15 and 25° S) and southern (between 25 and 35° S). The proportion of swordfish versus tuna catch was calculated using only the reported data.

3. Results

South Africa

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 east of 20° E. Observers recorded seabird bycatch 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 bycatch data on 34 sets. An average of 978 000 hooks were set per year throughout the fleet, 10% of which carried an observer. Fishing effort concentrated on the continental shelf and extended as far off shore as 1° E and 16° N (Fig. 1a). Observer effort however was focussed more on inshore trips and along the continental shelf (Fig. 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) (Fig. 2).

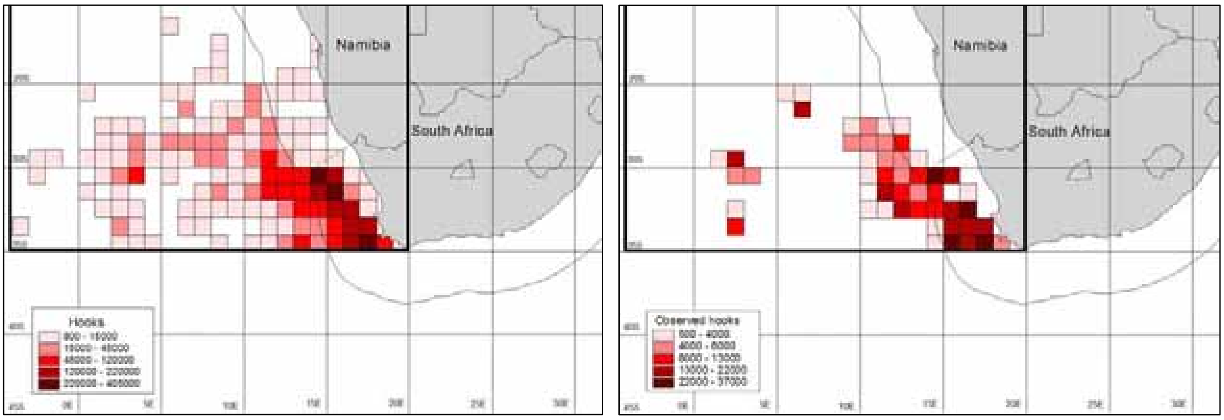

Fig. 1: a) Total and b) observed effort for the pelagic longline fishery (BCLME border is bold)

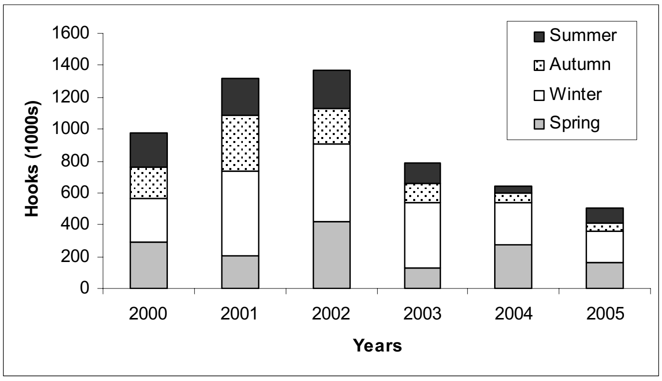

Fig. 2: Fishing effort in the pelagic longline fishery per year and season, 2000 and 2005

There was no significant difference in seabird catch rates between the two fleets (t=0.5, p=0.6) and seabird bycatch rates averaged 0.2 birds per 1000 hooks (2000-2005), thus killing approximately 196 per year. Albatrosses account for 69% of the birds caught (Table I). Shy Albatrosses were the most commonly caught, then Black-browed and Atlantic Yellow-nosed albatrosses. The remaining 31% comprised predominantly of White-chinned Petrels and Cape Gannets. The distribution of seabird bycatch in South African longline fisheries is shown by 1 X 1 degree grid squares in Fig. 3. Catch rates varied between 0.001 and 1.2 birds per 1000 hooks per grid square. Seabird bycatch is the highest in the south east and along the continental shelf (Fig. 3).

Table I: Seabird bycatch rates for the pelagic longine fishery and species composition, 2000 to 2005

Species		**Bycatch 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/ 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%**

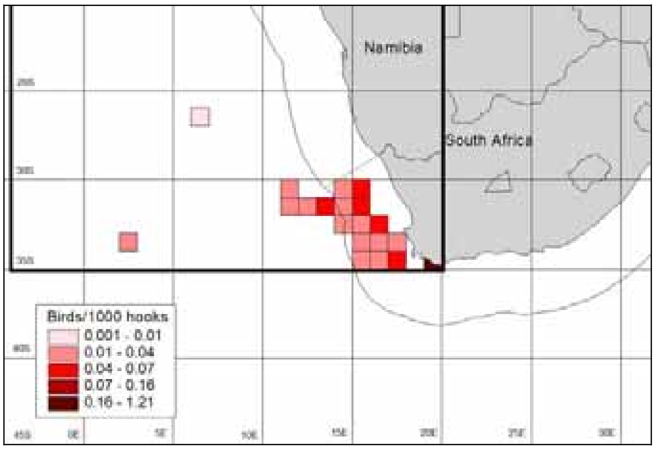

Fig. 3: The distribution of seabird bycatch according to observer data (South African and Asian flagged vessels), 2000 to 2005

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.

Demersal longline fishery

Just over 36 million hooks were set from 2000 to 2004 and effort ranged between 6 and 13 million hooks (average 8.3 million hooks) on 4 276 sets (average 855) annually between 2000 and 2004 (Table IV) east of 20 ° E. 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 ($\chi^2 = 130879$, $p<0.001$) and season ($\chi^2 = 847974$, $p<0.001$) (Fig. 4).

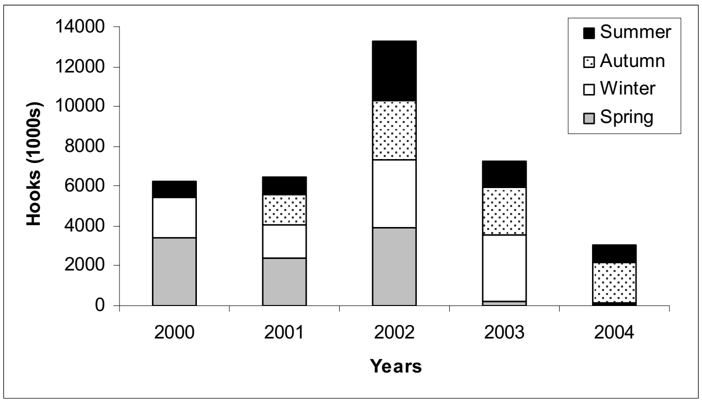

Fig. 4: Fishing effort in the pelagic longline fishery per year and season, 2000 to 2004

There was no seabird bycatch reported in 2000 and 2001. A total of 46 birds were caught at a rate of 0.06 birds per 1 000 hooks from 2002 to 2004. Over the entire time period catch rates remained at 0.04 birds per 1 000 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 the total. Cape Gannets were the second most commonly caught (11%) at a catch rate of 0.004 birds per 1000 hooks, but most were released alive. For albatrosses, catch rates were combined because of their low percentage contribution (7%) to the overall seabird bycatch (0.002 albatrosses per 1000 hooks). An extrapolated 301 seabirds are caught by the demersal longline fishery per year (Table II).

Table II: Seabird bycatch 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 Albatross	*Thalassarche melanophrys*	unknown	-	-
Yellow-nosed Albatrosses	*Thalassarche chlororhynchos/ 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%**

Data was collected from hake longline trips conducted during 2005 from a total of 116 480 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 was 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 were seldom used during 2000 and 2004. According to observer reports, they were flown in 12% (n = 210) of all sets.

Namibia

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 (Fig. 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, occurs 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.

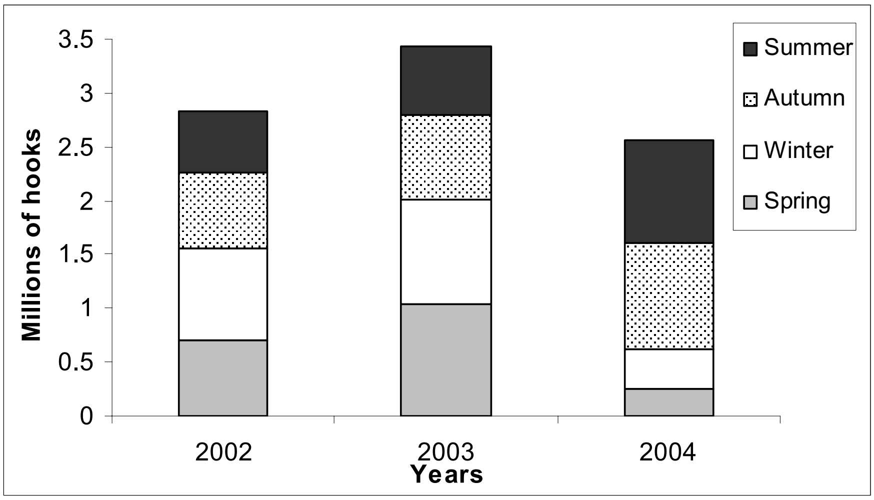

Fig. 5: Number of hooks and sets per season and year set by Namibian pelagic longline vessels, 2002 to 2004

Bycatch data from Namibian fisheries is 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 1 000 hooks were incidentally caught. The line supported between 2 700 and 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 the 9th and 23rd of June 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, Atlantic Yellow-nosed and Shy albatrosses, White-chinned Petrels and sub-Antarctic Skuas (Table III).

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

Species		**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
Atlantic Yellow-nosed Albatross adult	*Thalassarche chlororhynchos*	11	10
Atlantic 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

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

Demersal longline fishery

Approximately 25 wet fish vessels operate out of both Walvis Bay and Luderitz depending on the availability of fish. This fishery sets, on average approximately 104 million hooks or 6040 sets annually. Effort remained fairly constant over the time period (Fig. 6). Note that the data for 2004 is 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.

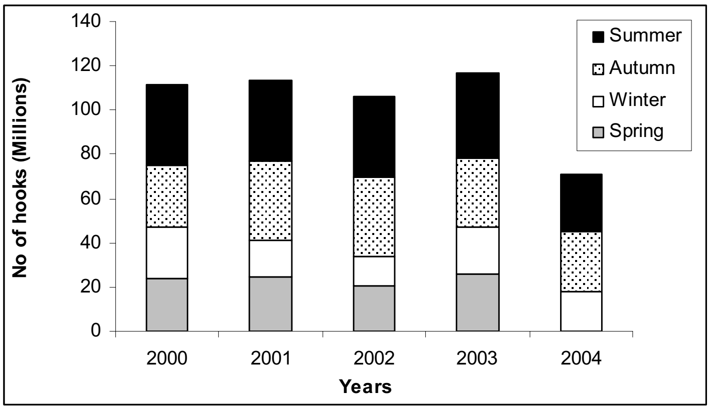

Fig. 6: Number of hooks set per season and year by Namibian demersal longline vessels, 2000 to 2004

Observers were not required to collect information regarding seabird mortalities. However, of the 13 observers interviewed, 12 reported that they felt seabird bycatch was unacceptably high and resulting in population decreases. Estimations of seabird bycatch 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 during an 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 observer collected information from a fisheries' patrol vessel from 4 August 2003 to 11 September 2003. Two demersal longliners were observed for four hours each during hauling process. No seabird mortality was recorded. A second voyage was conducted from 26 September 2003 to 5 October 2003 on a hake longline vessel. During the trip, one seabird was caught. No species identification was made. This translates to a catch rate of 0.01 birds per 1000 hooks. A third trip was conducted in November 2006. Five sets or 93 000 hooks were observed. Sixty-two White-chinned Petrels were caught at a rate of 0.65 birds per 1000 hooks. Based on this data we estimate an average catch rate of 0.3 birds per 1000 hooks. Since the total effort in this fishery is on average 104 million hooks per year and we estimate that approximately 30 650 birds are caught by this fishery each year. The observer also sighted numerous Cape Gannets and a Yellow-nosed Albatross entangled in fishing gear.

Angola

Seabird bycatch is likely to occur in coastal artisanal subsistence, semi-industrial 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 has increased dramatically from about 14 000 tons is 1999 to between 40 000 and 50 000 tons in 2002 and 2003 respectively.

Seabird bycatch during the fishing operations are not recorded in these fisheries, which are operated by foreign vessels and use distant ports. No data therefore exists on the rates of bycatch. Fishing effort average 3.5 million hooks annually (ICCAT: 2000 to 2004) in the southern region of Angola (South of 15º S) 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 was 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 bycatch. 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 per set. This was confirmed by interviewees and observers onboard the *F. Nansen* (September 2002). This fishery targets 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 sea 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.

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 and approximately 30 850 birds are killed by the demersal longline fleets fishing in the Benguela each year. Based on these estimates the total impact of these two national fleets is approximately 31 350 birds per year (Table IV). However, these are not the only two nations fishing within this region.

Table IV: Seabird bycatch per fishery and per country

Species	Seabird byatch per longline fishery sector (confidence rating)						Minimum per annum**	IUCN category	Status
	South African Pelagic (high)	*South African Demersal (high)*	*Namibian Pelagic (medium)*	*Namibian Demersal (medium)*	*Angolan Pelagic (poor)*	*Angolan Artisanal handline (poor)*			
Shy Albatross	0.07	Recorded	Recorded	Recorded	Possible, but likely to be rare	Possible, but likely to be rare	>899	Near Threatened	Unknown
Black-browed Albatross	0.03	recorded	Recorded	Recorded	Possible, but likely to be rare	Possible, but likely to be rare	>58	Endangered	Decreasing
Atlantic Yellow-nosed Albatross	0.02	0.0015	Recorded	Recorded	Likely	Likely	>203	Endangered	Decreasing
Other Albatrosses	0.01	0.0008					>174		
Total Albatrosses	0.13	0.002					>1334		
White chinned Petrel	0.02	0.02	Recorded	0.3	Likely	Recorded	>31 903	Vulnerable	Decreasing
Other petrels	0.02	0.01					>580		
Total Petrels	0.04	0.03					>1537		
Cape Gannet	0	0.004	Recorded	Recorded	Likely	Recorded	>33*	Vulnerable	Decreasing
Total Seabirds	0.2	0.04	0.07	0.3	Unknown	Unknown	>33 850		

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

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

Table V: 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%

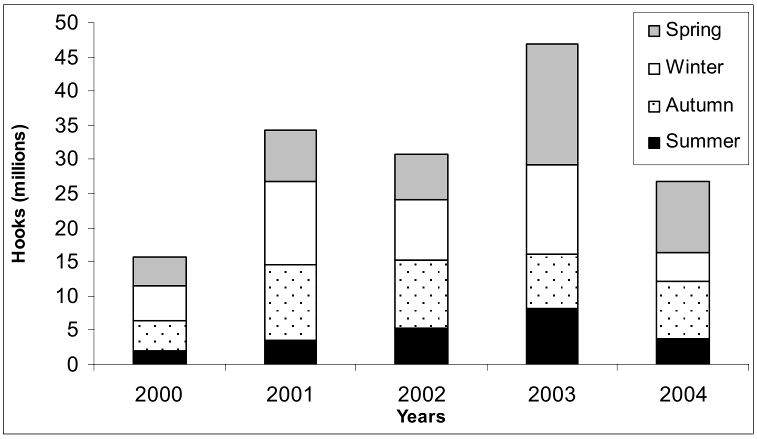

Fig. 7: Seasonal and annual trends in effort data for the Benguela region, 2000 to 2004 (based on ICCAT data)

Based on the South African catch rate of 0.2 birds per 1000 hooks 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 V). Similarly for the mid region we base the catch rate on the estimate of 0.07 birds per 1000 hooks from the Namibian fishery (Table VI). Effort for this region is approximately 10 million hooks per annum; therefore we estimate seabird bycatch to be approximately 700 birds per annum. It is unlikely that albatrosses are caught in substantial numbers north of 15° S, although the extent to which petrels (e.g. white-chinned petrels) are caught is unknown. Therefore, we conservatively estimate that approximately 2 900 birds are caught by the pelagic longline fishery operating throughout the Benguela per annum (Table IV). Thus total seabird mortality for all longline fleets i.e. both demersal and pelagic may kill 33 850 birds per year (Table IV).

Table VI: 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**

4. 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 about the sustainability of these populations. 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 south west 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 approximately 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 it 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 BCLME 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 north-eastern 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, according to IUCN criteria, 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. These reports highlight 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 (Watkins *et al* 2006). 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 BCLME (South Africa, Namibia and Angola) are no exception. South Africa has an effective observer programme which has been collecting data on fishing operations, including bycatch, since 2000. Consequently the most reliable and comprehensive data for the region comes from this programme. However, since seabird abundance and species composition is 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 1 000 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 across 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 0.3 birds per 1 000 hooks in the Namibian fishery. A higher catch rate is consistent with information gained from interviews 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 the likelihood of catching a bird per set. As target 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 become hooked for longer periods. Furthermore, South African vessels are required by law to use bird-scaring lines, a mitigation measure to reduce seabird bycatch, further supporting a lower bycatch rate observed in the South African fleet compared with Namibia where no such permit conditions exist. Moreover, the reliability of the total estimate of 30 650 birds killed by this fishery relies on the accuracy of the total fishing effort which according to the data supplied is higher than that recorded in South African waters. However, it should be borne in mind that only effort west of 20 ° east is used for calculations of seabird mortality for South African fleets. Nevertheless, the possibility exists that the accuracy of logbook data supplied does not reflect true effort in Namibian waters.

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 region 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 were 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 8 000 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 1 000 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 bycatch 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 bycatch 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.

5. References

ABBOTT, C. L., DOUBLE, M. C., BAKER, G. B., GALES, R., LASHKO, A., ROBERTSON, C. J. R. and P.G., RYAN. 2006 – Molecular provenance analysis for shy and Shy albatrosses killed by fisheries interactions in Australia, New Zealand and South Africa. Conservation Genetics, DOI 10.1007 per s10592-005-9064-y.

ALEXANDER, K., ROBERTSON, G. and R. GALES. 1997 – The incidental mortality of albatrosses in longline fisheries. Australian Antarctic Division Tasmania

BAKER, G. B., TUCK, G.N., ABBOTT, C. L., DOUBLE, M.C., GALES, R., RYAN, P.G., ROBERTSON, C.J.J.R., BAIRD, S-J., ALDERMAN, R. and S.L. PETERSEN. In press – Conservation implications of fisheries-related mortality on shy and Shy albatrosses. *Biological conservation*

BARKER, M.J. and V. SCHLUESSEL. 2005 – Managing global shark fisheries: suggestions for prioritizing management strategies *Aquatic Conserv: Mar. Freshw. Ecosyst*. **15**: 325–347

BARNES, K.N., RYAN, P.G. and C. BOIX-HINZEN. 1997 – The impact of the Hake *Merluccius* spp. Longline fishery off South Africa on procellariiform seabirds. *Biological Conservation* **82**: 227-234

BIRDLIFE INTERNATIONAL 2005. In: IUCN 2006. *2006 IUCN Red List of Threatened Species.* www.iucnredlist.org.

COOPER, J. and RYAN, P.G. 2005 – Draft South African National Plan of Action for Reducing the Incidental Catch of Seabirds in Longline Fisheries. Marine and Coastal Management Department of Environmental Affairs and Tourism South Africa. www.environment.gov.za. 98 pp. www.environment.gov.za. 98 pp

CORDES, I.G. 1996 – Seabird populations and breeding localities along the Namibian coast. In: *Annual research meeting 20 –22 February 1996 MFMR*.

CRAWFORD, R.J.M., RYAN, P.G. and WILLIAMS, A.J. 1991 – Seabird consumption and production in the Benguela and western agulhas ecosystems. *S. Afr. J. Mar. Sci.* **11**: 357-375

CRAWFORD, R.J.M., BENEDICT, L.D., DYER, B.M., KLAGES, N.T.W., MEŸER, M.A. and L. UPFOLD. in press. Trends in numbers of cape gannets (*Morus capensis*) 1956 per 57–2005 per 06 with a consideration of the influence of food and other factors. *ICES Journal of Marine Science*

CROXALL, J.P. and R. GALES. 1998 – An assessment of the conservation albatrosses. In: Robertson G and Gales R (Eds). Albatrosses biology and conservation. Chipping Norton: Surrey Beatty and Sons. pp 46-65

CUTHBERT, R., RYAN, P.G., COOPER, J. and HILTON, G. 2003 – Demography and population trends of the Atlantic yellow-nosed albatross. *The Condor* 105: 439-452

DURATE, A. 2005 – By catch of threatened seabirds sharks and turtles in long line fisheries in the Benguela Large Marine Ecosystem (BCLME) – Angola Report BCLME Project BEHP per EEF per 03 per 01 02 Instituto de Desenvolvimento da Pesca Artesanal Rua José Pedro Tuca Nº 36 per 38 Cx. Postal 6776 Luanda – Angola

FAO 1999 – Indicators for sustainable development of marine capture fisheries' FAO Technical Guidelines for Responsible Fisheries No. 8 FAO Rome. Available at www.fao.org

GALES, R. 1998 – Albatross populations: status and trends. In: Robertson G and Gales R (Eds). Albatross biology and conservation. Chipping Norton: Surrey Beatty and Sons. Pp. 20-45

HARRISON, P. 1983 – *Seabirds: an identification guide*. Beckenham, U.K.: Croom Helm.

ICCAT 2005 – Compendium: management recommendations and resolutions adopted by ICCAT for the conservation of Atlantic tunas and tuna-like species. Available at www.iccat.es

MELVIN, E.F., SULLIVAN, B., ROBERTSON, G. and B. WIENECKE. 2004 – A review of the effectiveness of streamer lines as a seabird by-catch mitigation technique in longline fisheries and CCAMLR streamer line requirements. *CCAMLR Science* **11**: 189-201.

NEL, D.C. and F.E. TAYLOR. 2002 – Globally threatened seabirds at risk from longline fishing: international conservation responsibilities. Manuscript submitted to FAOCOFI 2002. BirdLife International Seabird Conservation Programme Cape Town 15pp.

OLMOS, F., BASTOS, G. C. C. and DA SILVA NEVES, T. 2000 – Estimating seabird bycatch in Brazil. Second International Conference on the Biology and Conservation of Albatrosses and other Petrels, 8-12 May 2000. Honolulu, USA.

PETERSEN, S.L. 2004 – Initial bycatch assessment: South Africa's domestic pelagic longline fishery 2000-2003. BirdLife per WWF Responsible Fisheries Programme report.

ROBERTSON, G. 1998 – The culture and practice of longline tuna fishing: implications for seabird by-catch mitigation. *Bird Conservation International* **8**: 211-221.

ROBERTSON, C.J.R., BELL, E.A., SINCLAIR, N. and B.D., BELL. 2003 – Distribution of seabirds from New Zealand that overlap with fisheries worldwide. New Zealand Department of Conservation Science for Conservation Series 233. Department of Conservation, Wellington.

ROUX, J-P., DUNDEE, B. and D.A. SILVA J. 2005 – Seabirds and marine mammal distribution and abundance. BCLME Project Report LMR per EAF per 03 per 02

RYAN, P.G. and C. BOIX-HINZEN. 1998 – Tuna longline fisheries off southern African: the need to limit seabird bycatch. South African Journal of Science **94**: 179-182.

RYAN, P.G. and B. ROSE. 1995 – Migrant seabirds. In Oceans of life off Southern Africa. (eds) Payne IL Crawford RJM van Dalsen AP. Pp 274

RYAN, P.G., KEITH, D.G. and M. KROESE. 2002 – Seabird bycatch by Tuna longline fisheries off southern Africa 1998-2000. *S. Afr. J. Mar. Sci.* **24**: 103-110

SHANNON, L.V. and M.J. O'TOOLE: 2003 – Sustainability of the Benguela: ex Africa simper aliquid novi. Published in Large Marine Ecosystems of the World: Trends in Exploitation Protection and Research G. Hempel and K. Sherman eds.. Elsevier B.V. 227-253.

TICKELL, W.L.N. 2000 – Albatrosses. pica press Sussex

VOGES, L. 2005 – Bycatch of threatened seabirds sharks and turtles in longline fisheries in the Benguela large marine ecocystem (BCLME): an integrated approach initial assessment report of the longline fishery and the potential bycatch of seabirds turtles and sharks for Namibia

WATKINS, B.P., PETERSEN, S.L. and RYAN, P.G. 2006 – Interactions between seabirds and deep water hake trawl gear: An assessment of impacts in South African waters in 2004-2005 Report to the South African Deep Sea Trawling Industry Association

WEIMERSKIRCH, H. and P. JOUVENTIN. 1998 – Changes in population sizes and demographic parameters of six albatross species breeding on the French sub-Antarctic islands. Pp. 84-91 in G. Robertson and R. Gales, eds. *Albatross biology and conservation*. Chipping Norton, Australia: Surrey Beatty and Sons.

WEIMERSKIRCH, H. 2004 – Diseases threaten Southern Ocean albatrosses. *Polar Biol.* **27**: 374-379.

Sea Turtles

The impact of pelagic longline fisheries on sea turtles in the Benguela Current Large Marine Ecosystem

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Research efforts on the incidental capture of several species of sea turtles by commercial longline fishing activities in the South East Atlantic are few. In this paper, we present a bycatch assessment for sea turtles caught incidentally by longline fishing activities in the Benguela Large Marine Ecosystem (BCLME). We integrate data from observer reports, surveys and specialized trips from the coastal countries of South Africa, Namibia and Angola. Total effort was obtained from ICCAT and stratified by 5 degree grid squares. Total sea turtle bycatch based on this effort, was estimated between 7 600 and 120 700 sea turtles per annum. However sea turtle abundance is not consistent throughout the region. For this reason we estimated sea turtle bycatch in the southern and central Benguela (south of 15 º south) as 4 200 turtles caught per annum based on the catch rates recorded in the South African pelagic longline fishery. No sea turtle bycatch data exists for Angola. However as many as 35 000 sea turtles could be caught per annum in the northern Benguela if the catch rate provided by Lewison et. al (2004) for the Atlantic is applicable for this region.

Key words: *sea turtle bycatch, longline fishing*

1. Introduction

Five species of sea turtles are known to occur within Benguela Current Large Marine Ecosystem (BCLME) (Payne *et al.* 1995). Three of these species (green *Chelonia mydas*, olive ridley *Lepidochelys olivacea* loggerhead *Caretta caretta*) are classified as endangered, whilst the remaining two are classified as critically endangered (leatherback *Dermochelys coriacea*, hawksbill *Eretmochelys imbricate*) according to the IUCN red listing criteria (IUCN 2006). Despite this, little is known of the behaviour of these species in the BCLME and even less known about at sea threats to these species whilst in this productive feeding area.

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The BCLME is characterised by strong coastal upwelling and high productivity (Hutchings *et al.* 1995). This eastern boundary current system is uniquely bound at both ends by the tropical warm waters of the Agulhas in the south and the Angola current to the north (Shannon and Nelson 1996). The main area of upwelling, along the Namibian and South African coast, between 16º and 34º S, is generated by southeast trade winds (Shannon 1985a). Its unique bathymetry, hydrography, chemistry and trophodynamics combine to make it one of the most productive ocean regions in the world supporting an important global reservoir of biodiversity and biomass of zooplankton, fish, seabirds, marine mammals and sea turtles (Shannon and O'Toole 2003). In turn this system also supports a range of fishing activities that exploit its resources.

In South African waters two species, the loggerhead and leatherback turtle nest along the north east coast of South Africa (Payne *et al.* 1995). The green turtle occurs as a non-breeding resident in South African waters, whilst hawksbill and the olive ridley turtles are not frequently encountered. Leatherback and loggerhead turtles are expected in higher abundance in the Benguela and lower Agulhas when they are returning from their nesting grounds to forage, during February and August (Nel pers. comm.). Satellite tracking studies have also shown movements of leatherback turtles from their nesting sites in the south west Indian Ocean, into the Benguela, even as far as 26º S in Namibia (Luschi *et al.* 2003).

In Namibia the most frequently encountered turtle species are the green and leatherback turtles, both of which have been known to occur primarily north of the 22º S (Hughes *et al.*1973, Hughes 1982). Particularly large aggregations of juvenile and adult green turtles have been recorded at the Cunene river mouth on the Namibian - Angolan border (Hughes *et al.* 1973). Loggerhead and hawksbill turtles have also been reported in Namibian waters, but it is unlikely that any of the four species nest here (Fretey 2001).

Of the five turtle species documented to occur within Angolan waters (namely the loggerhead, leatherback, green, hawksbill, olive ridley) only the green, olive ridley and leatherback turtles are confirmed to breed (Hughes *et al.* 1973, Carr and Carr 1991, Fretey 2001). High nesting densities of these three species, reaching 30 crawls on a 500m stretch of beach, have been recorded in the past (Hughes *et al.* 1973). Interviews with fishermen indicate that turtle nesting activity begins in September, and peaks between November and March (Carr and Carr 1991). Olive ridley is the most wide-spread and regularly encountered of all the turtle species in Angola. It is confirmed to nest along the entire coast from Cabinda in the north to the Cunene River in the south (Hughes 1982). At-sea sightings of this species were reported at the Bay of Bengo and the Bay of Cabinda (Carr and Carr 1991). This species has been the most frequently reported as bycatch in fishing nets (Ron unpublished). Leatherback turtles nest primarily in the northern and central regions of Angola (Fretey 2001), but have also been reported to nest from Cabinda south to Baia Farta (Hughes *et al.* 1973, Carr and Carr 1991). Green turtles were reported to nest on the southern coast of Angola and sightings of juveniles and adults at foraging sites indicate an important nursery location at the Mussulo Bay and the Kunene river mouth (Carr and Carr 1991, Ron unpublished). Loggerhead nesting was rare and observed only on the northern Angolan coast (Ron unpublished).

Sea turtles are long-lived and have low reproductive capacity due to high juvenile mortality rates (Spotila 2004). Moreover, they travel large distances and thus encounter many fishing operations (Spotila 2004). These factors combined make them especially vulnerable to overexploitation and fishing mortality. In the past, research has focused on land–based threats, such as nesting habitat alteration and harvesting of adults and eggs. However, more recent research has recorded alarming levels of mortality in various fishing operations, including pelagic longline, drift-netting and pelagic trawling (Aguilar *et al.* 1995, Nichols *et al.* 1999, Silvani *et al.* 1999, Witzell 1999, Camiñas *et al.* 2006). Globally, unsustainably large numbers of sea turtles, particularly leatherbacks (200 000 per annum) and loggerheads (50 000 per annum), are taken as bycatch by pelagic longline fishing (Lewison *et al.* 2004). Longline bycatch rates of these two species have been identified as the main cause of their population declines (Crowder 2000, Spotila *et al.* 2000, Kamezaki *et al.* 2003, Limpus and Limpus 2003). High catch rates of sea turtles in longline fisheries in the Atlantic have been observed in regions such as the Gulf of Guinea (Carranza *et al.* 2006), southern Brazil (Pinedo and Polacheck 2004) and the western North Atlantic, where estimates of annual catch of sea turtles in the US Atlantic longline fleet range from 800 to 3000 between 1992 and 2000 (Witzell 1996, Yeung 1999, Yeung 2001). However, few data exist on sea turtle bycatch in other pelagic longline fisheries active in the Atlantic.

Studies have been conducted in the Benguela concerning the bycatch of sea turtles. Petersen (2005) reported the incidental capture of four (loggerhead, leatherback, green and hawksbill) of the five species occurring in South African waters in longlines between 2000 and 2003 at a rate of 0.06 sea turtles per 1000 hooks. Only the olive ridley was not reported. Accounts of sea turtle bycatch in Namibia are few. However, all four species have been reported as bycatch in longline, gillnet, and trawl fisheries (Bianchi 1993, Fretey 2001). In Angola, random sea turtle bycatch cases have been identified. A study conducted by Afonso (1987) in the fishing communities close to Bay of Mussulo and adjacent areas, revealed the carapaces of 49 sea turtles, 17 green and 32 olive ridley. Later it was confirmed that intense artisanal gillnet and purse seine fishing occurs within the Bay, which was also identified as a popular nursing and foraging site for adult and juvenile green turtles (Ron unpublished). Bycatch of this species was recorded throughout the year of 1987. A survey conducted on a 54 km long beach site during 2003 and 2004 at the Beach da onça in Palmerinhas, revealed that the 92 carcasses of sea turtles surveyed had been dumped from commercial trawl fishing vessels located inshore in the region (Afonso *et al.* unpublished; Weir *et al.* unpublished).

This paper represents the first comprehensive attempt to evaluate the impact longline fisheries (both industrial and artisanal) have on the sea turtles within the BCLME. The CPUE of sea turtles by South African pelagic longline fleets operating on the west coast of South

Africa is calculated. Since numerous distant water fleets operate within the BCLME, the impact of these fleets was estimated from the South African estimate, and other estimates reported in the literature, and extrapolated for total effort obtained from International Convention for the Conservation of Atlantic Tunas (ICCAT). Management and research recommendations are made, based on our findings.

2. Methods

Shannon and O'Toole (2003) define the boundaries of the BCLME as the 0º meridian in the west, and 27º E in the east. However, for purposes of practicality we have used an eastern boundary to 20º E as this is a management and data reporting boundary for South African fisheries. The Southern boundary is defined as the Agulhas current at 35º S and the northern boundary at 5º S, incorporating the full extent of the Angolan and Namibian EEZ's (Shannon and O'Toole 2003).

Effort data

Effort data for pelagic longline fishing in South Africa and Namibia used in this study were taken from the national observer programmes and logbook records, made available by the South African Department of Environmental Affairs and Tourism and the Namibian Ministry of Marine Resources. Chi-squared tests were used to compare effort between years and seasons for the time period.

Commercial longline fishing effort reported to ICCAT in the Benguela region for the period 2000-2004, was downloaded from the ICCAT public domain website (www.iccat.es). This data set lists fishing effort per 5º × 5º square per nation per month. Included with this data is catch (tuna, swordfish and shark) per weight and per number.

No effort was reported for some fleets operating in the Benguela despite the fact that these vessels contributed 15% of the total catch of tuna and swordfish (ICCAT 2006). We therefore used the average catch rates of tuna and swordfish for all nations to extrapolate the average annual effort by these nations per 5º × 5º. This corrected average annual number of hooks set in the Benguela was used in the analyses. For extrapolating a total sea turtle bycatch for the Benguela the effort is divided into three regions namely northern (between 5 and 15ºS), mid (between 15 and 25º S) and southern (between 25 and 35º S) region. Catch and effort data was stratified by 5 degree grid squares. Chi-squared tests were used to compare effort between years and seasons for the time period.

At-sea data collection

Bycatch data were collected by fisheries' observers on board pelagic longline vessels targeting tuna and swordfish from 2000 to 2005 in South Africa. These vessels carried rights to fish within South Africa and on the high seas. No bycatch data exists for the Namibian fleet. Further information was collected by specialised scientific observers from the Birdlife and WWF Responsible Fisheries Programme in South Africa and Namibia. Number of sea turtles caught per 1 000 hooks was calculated for South African vessels targeting tuna and swordfish in the BCLME. Chi-squared tests were used to compare catch-rates between years and seasons for the time period.

Interviews

Between March and August of 2006, interviews were conducted with skippers, permit holders and shore skippers to record the perceived level of bycatch of sea turtles in the South African and Namibian pelagic longline fisheries. The format of the questionnaire was standard for both countries. The interviews took 1,5 hours each to complete and collected data detailing gear and operational information, incidental capture of seabirds, sea turtles and sharks and bycatch mitigation. Key questions included:

1) How many turtles do you capture per trip?
2) Are the turtles dead or alive when captured?
3) In your opinion, is this rate of capture threatening the species?
4) What depth do you set your gear at?
5) What bait do you usually use, and which of these bait types caught more turtles?

In Angola, interviews were carried out in the coastal communities of Namibe Province between 19 and 21 January 2005 to assess the level of bycatch of sea turtles in local artisanal longline fisheries in these provinces. The areas surveyed were in the close surrounds of Namibe (Sack-sea to Salinas Barreiros), Tômbwa district (Tômbwa and the Black Cable community) and the community of Mucuio. One day was spent interviewing fishermen, trappers and coastal residents in each location. Data collected included the species and number of sea turtles occurring in the region, the seasonality of their occurrence, the number captured on longline hooks and the use of captured animals.

Estimating overall impacts

No observed bycatch data was available for commercial pelagic longliners in Angola and very limited data for Namibia. We therefore relied on sea turtle catch rates estimated in this study for the Benguela portion of South Africa and that reported in the literature in an attempt to estimate total catches in the region. Lewison *et al.* (2004) reported the global catches of loggerhead and leatherbacks separately, thus to account for total estimated sea turtles caught in the Benguela region, the catch rates for those two species were totalled prior to the extrapolation. Lewison *et al.* (2004) reports a range of numbers of leatherback and loggerhead turtles caught globally and for the Atlantic, only the lowest estimates in the range were used in this investigation and serve as a minimum.

3. Results

South Africa

South African vessels using the American longline system targeting swordfish *Xiphias gladius* during 2000 and 2005, set a total of 5 593 600 hooks in 4 063 sets between 2000 and 2005. The total fishing effort fluctuated each year (% observed hooks in parentheses): 23 700 (2%) hooks set in 2000, 131 700 (10%) hooks set in 2001, 104 000 (8%) hooks set in 2002, 73 800 (9%) hooks set in 2003, 14 400 (2%) hooks set in 2004 and 100 000 (20%) hooks set in 2005. Thus an annual average of 932 300 hooks of which 8% were observed, were set in this period. Twenty-five vessels carried an observer during this time period and a total of 330 sets were observed. Vessels using the Asian longline system and predominantly targeting tuna species set a total of 278 900 number of hooks in 100 sets between 2000 and 2005. On average, 46 500 hooks in 20 sets were set per annum. The total fishing effort fluctuated each year (% observed hooks in parentheses): 27 800 (0%) hooks set in 2000, 26 000 (58%) hooks set in 2001, 14 900 (0%) hooks set in 2002, no hooks set in 2003, 153 800 (0%) hooks set in 2004 and 56 400 (100%) hooks set in 2005. Eight vessels carried an observer during this time period and a total of 72 500 hooks were observed.

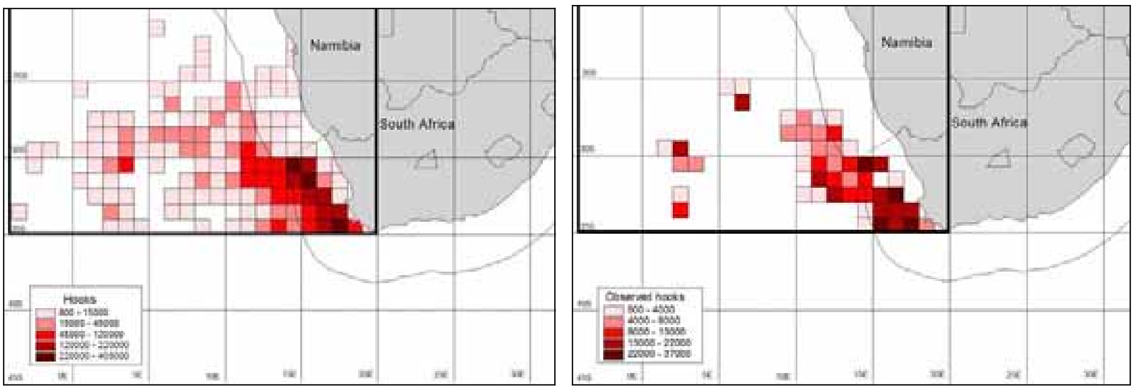

Fig. 1: a) Total and b) observed effort for the South African pelagic longline fishery (BCLME border is bold)

During the period 2000 and 2005, a total of 375 (341 swordfish and 34 tuna) sets and 520 000 hooks were observed. Observed effort was concentrated in a similar area to where total reported fishing effort took place (Fig. 1 a and b). A total of 118 sea turtles were caught.

Of the five species reported to occur in South African waters, four of these were caught (loggerhead 60%, leatherback 16%, green 2%, hawksbill 3%, unidentified 19%). Catch rates were the highest in 2002 (0.76 sea turtles per 1000 hooks) and no sea turtles were caught in 2000 and 2004. However, catch rates were not significantly different between years (χ^2 =0.184, p>0.05, df = 5) or seasons (X^2 = 0.606, p>0.05, df = 3). Most (95%) sea turtles caught were returned to the ocean (18% alive, 82% dead). The remaining 5% were retained. Sea turtles were only caught on longline vessels targeting swordfish. The overall catch rate for swordfish vessels operating along the west coast of South Africa was 0.2 sea turtles per 1 000 hooks for the study period (2000-2005). Sea turtles were primarily caught outside of South Africa's Exclusive Economic Zone (EEZ) (Fig. 2). With an annual average effort of 979 000 hooks per annum during this period it is estimated that an average of 223 sea turtles could be caught per annum by South African pelagic longline vessels operating in the BCLME.

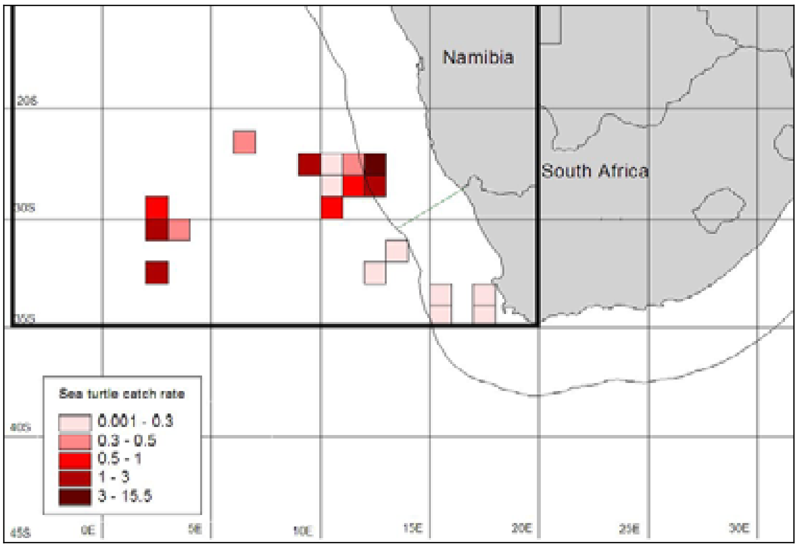

Fig. 2: Sea turtle catch rates in 1°×1° grid squares from observed sets, 2000 to 2005.

A specialised scientific observer collected data from two commercial pelagic longline vessels targeting swordfish *Xiphias gladius* off the west coast of South Africa during April and May 2006. The observed effort totalled 32 990 hooks. A total of four sea turtles, two leatherback and two loggerhead, were caught on three sets. The catch rate therefore averaged at 0.1 sea turtles per 1000 hooks. They were caught on squid bait, either in mouth or on the flipper, and were released alive. One of those released alive was very weak and unlikely to survive.

Three skippers, two permit holders and one shore skipper operating out of Cape Town harbour, South Africa were interviewed on the subject of bycatch in the commercial pelagic longline fishery. Five of the interviewees confirmed that they had caught sea turtles in their gear at an average rate of 1-2 sea turtles per annum (0.005 sea turtles per 1000 hooks). Five of the interviewees reported that most sea turtles caught were released alive. Little awareness exists about mitigation methods to abate sea turtle bycatch, as confirmed by all interviewees in this study. Four of the interviewees reported that they had never used circle hooks nor carried a dehooker; however most vessels did have a line cutter on the vessel. Squid is the primary bait type used in this fishery as confirmed by all the interviewees.

Namibia

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. The Namibian pelagic longline fishery targets swordfish *Xiphias gladius*, shortfin mako shark *Isurus oxyrinchus*, blue shark *Prionace glauca* and tunas *Thunnus albacares, Thunnus obesus* and *Thunnus alalunga*. The gear used by this fishery is very similar to that of the South African pelagic longline fishery with minor gear refinements that are adapted to catch sharks at shallower depths (e.g. wire traces, shorter branchlines). The mainline is generally over 85 km in length, made of either monofilament or polypropylene nylon. It is usually set at dusk and is allowed to soak until dawn. Floats, of which there are on average 462 (including radio buoys), are generally spaced at 35-50 m apart and are approximately 7 m long. There are approximately six 10.5 m long branchlines between buoys, spaced at approximately 40 m apart. On average 1 964 (range 4 200-340, std dev 836) hooks are attached to the mainline. The separate parts that make up the total are the upper section (6.8 m) and trace (3.7 m), separated by a 60 gram swivel. Lightsticks are attached to approximately 41% of the branchlines. Either a combination of mackerel, horse mackerel and squid or mackerel alone was used as bait. The trips are between 30 and 35 days with equally as many sets per trip. The vessels are freezer vessels with a length range between 20 and 55 m (average length 28 m).

Fisheries' observers did not collect any data on sea turtle bycatch. A specialised scientific observer collected at-sea data from 38 000 hooks (18 sets) from two commercial fishing vessels operating from Walvis Bay in June 2006. These trips took place between 19°S and 26°S. The vessels averaged 26 m long and were flagged from Namibia and Spain. 15 lines (30 770 hooks) and three lines were observed on the Namibian and Spanish vessels respectively. The Namibian fishing gear consisted of a monofilament longline, approximately 40 miles long, with an average of 2 100 hooks. A combination of squid and fish such as mackerel and horse mackerel was used as bait. The Spanish vessel's gear consisted of a polypropylene longline, approximately 72 miles long, with an average of 2 383 hooks at a depth of 21 m. No sea turtles were caught on either trip. However, both skippers estimated that they catch an average of two sea turtles per trip lasting 30-45 days or 0.03 sea turtles per 1000 hooks (90 sea turtles annually based on 2.9 million hooks per annum). Using the CPUE calculated from South African observer data (0.2 sea turtles per 1000 hooks) we estimate 670 sea turtles may be caught per annum in the Namibian pelagic longline fishery.

Angola

There are two line fisheries operating in Angola that may impact sea turtles, the artisanal coastal subsistence line fishery and the industrial pelagic longline fishery. Between 2000 and 2002, 18 foreign pelagic longline vessels respectively, operated in Angolan waters under a bilateral agreement with the European Union. This increased to 25 foreign vessels between 2002 and 2004, and was terminated in 2004. At present only one Angolan flagged vessel is in operation. A further agreement with foreign flagged vessels is under discussion (Duarte pers. comm.). No bycatch data was collected as no formal observer agency existed up until 2006, only anecdotal evidence of sea turtle bycatch incidents exists for this fishery.

Artisanal fishers use surface longline to target seabirds and gill nets and handlines to target seabream species (Sparidae), grouper species (Serranidae), Angola Croakers *Miracorvina angolensis*, Angola dentex *Dentex angolensis*, hake *Merluccius* species and pelagic fish such as sardine *Sardinella* and horse mackerel *Trachurus trachurus*. The artisanal fishery in Angola consisted of 2 078 vessels (2000-2001), 1 933 vessels (2002-2003) and 2 939 vessels (2004-2005).

Thirty fishers in Namibe, Tômbwa and Mucuio were interviewed regarding the capture of sea turtles in the artisanal fishery. All interviewees had observed sea turtles off Namibe Province and several localities were identified as known areas of turtle nesting (Table I). These areas coincide with the main fishing areas in Namibe. All the fishermen reported that they had caught sea turtles on their lines, but few and infrequently. Four of the five species present in Angolan waters, namely the olive ridley, leatherback, loggerhead and hawksbill turtles, were reported to have been caught, however identification was not verified. Sea turtles of all sizes were reported caught throughout the year, although the variation in size may suggest the observation of different species. Most of the captured sea turtles are used for consumption and a small percentage are used commercially (carapaces and oil). Some sea turtles were released back into the sea. For example at Mucuio the fishermen care for wounded sea turtles and later return them to sea. At Cabo Preto only juvenile sea turtles were returned to sea, while adults were killed for their meat.

Table I: Locality of known areas of turtle occurrence in Namibe Province, as identified by longline fishermen

Province	District	Local	Latitude	Longitude
Namibe	Namibe	Mucuio	14º52'S	12º08'S
		Altio	15º09'S	12º01'S
		Giraul	15º04'S	12º03'S
		Ponta Albina	15º54'S	11º38'S
		3 Irmãos	15º20'S	11º58'S
		Cabo preto	15º40'S	11º50'S
	Tômbwa	Restinga	15º45'S	11º42'S
		Salinas Barreiros	15º12'S	11º59'S
		Pinda	15º42'S	11º49'S
		Rocha Magalhães	15º39'S	11º51'S

Estimated overall impacts

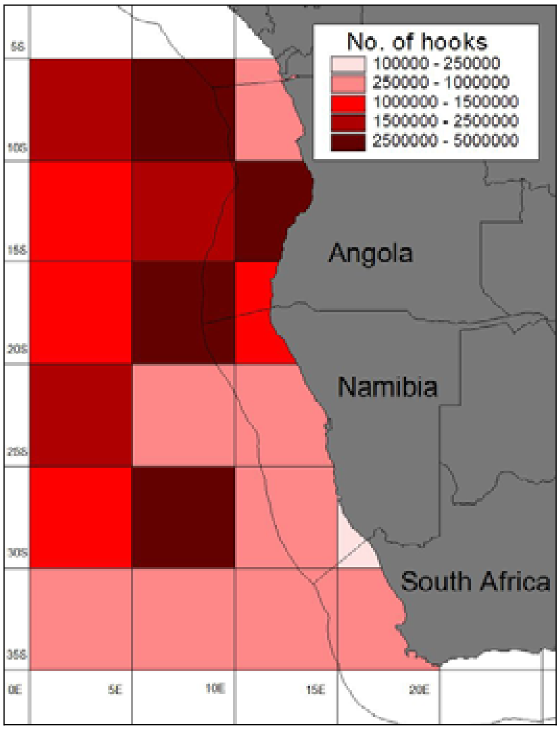

Fig. 3: Average annual pelagic longline effort in the Benguela LME, 2000 to 2004

Based on ICCAT data, the total effort for the Benguela for the period 2000 to 2004 was 172.4 million hooks at an average of 34 489 000 hooks per annum. Nine nations fished within the Benguela during this time, with Chinese Taipei contributing the highest proportion of effort (46.4%) and Japan the second highest (36.4%). No trends were found between seasons, however there was a significant difference in effort between years ($f=3.06$, $p<0.05$). An increase in effort from 2000 to 2003, followed by a decline in effort in 2004, was observed. The northern region of the Benguela, 5º S to 15º S constituted the highest proportion of effort of 67 571 000 hooks (39%, Fig. 3). The middle and southern regions, 15º S to 25º S and 25º S to 35º S, contributed 49 965 000 hooks (29%) and 54 910 000 (32%) respectively (Fig. 3).

A number of sea turtle bycatch estimates have been published (Table II). These estimates vary from 0.2 sea turtles per 1000 hooks (Witzell 1999, this study) to 3.5 sea turtles per 1000 hooks (Lewison *et al.* 2000). Extrapolations using these bycatch rates against the total annual longline fishing effort in the Benguela LME, give a range of between 7 600 and 120 600 sea turtles caught each year for the region.

Table II: Summary of the published bycatch rates of sea turtles (number per 1000 hooks) in longline fisheries globally

Reference	Catch rate (sea turtles per 1000 hooks)*	Date	Region	Turtle species	Fishery
Witzell 1999	0.2	1996	North Atlantic	All	U.S. Pelagic longline
This study	0.2	2000-2005	South Africa	All	Pelagic longline
Bravo *et al.* 2006	0.3	2003-2005	Peru	Mainly green and loggerhead	Pelagic longline
Camiñas *et al.* 2006	0.91	2006	Spanish Mediterranean	loggerhead	Pelagic longline
Carranza *et al.* 2006	1.02	May-Sept 2003	The Gulf of Guinea	All species, but mostly olive ridley	Pelagic longline
Lewison *et al.* 2004	2.4	2000	Global	loggerhead and leatherback	Pelagic longline
Lewison *et al.* 2004	3.5	2000	Atlantic*	loggerhead and leatherback	Pelagic longline

**data collected from US, Uruguay, Brazil and Taiwanese fleets fishing off North and West Africa*

4. Discussion

The accurate estimation of sea turtle bycatch in commercial longline fisheries and the impact that this has on threatened populations, remains a challenge for sea turtle researchers globally. Global bycatch assessments are few, and in many cases rely on limited data resources (Lewison and Crowder 2003, Lewison *et al.* 2004). A problem that is no different in the BCLME.

This paper sheds new light on bycatch rates of sea turtles in longline fisheries in the BCLME and the potential impacts on the affected species. A bycatch rate of 0.2 sea turtles per 1000 hooks was recorded for South African pelagic longline vessels operating in the region. This catch rate is considerably lower than catch rates reported elsewhere in the literature (Table II), and is thus likely to represent a minimum estimate. Simplistic extrapolation of this catch rate to the region indicates that approximately 7 600 sea turtles may be caught annually by pelagic longline fisheries operating in the BCLME. The highest catch rate reported in the literature is the estimate for the entire Atlantic reported by Lewison *et al.* (2004) which based on the effort in the Benguela totals 120 700 sea turtles caught per annum. In reality the estimate of sea turtle bycatch in the BCLME is likely to be between these two. Taking into account that sea turtle bycatch rates are up to ten times higher for pelagic longliners targeting swordfish than those targeting tuna (Crowder and Myers 2001), and based on ICCAT catch data for the Benguela, which revealed nine times more tuna-directed effort than swordfish, it is likely that sea turtle catch rates are moderate. The data available (34 sets from tuna targeting vessels in the South African pelagic longline fleet) was too small to detect sea turtle bycatch and thus did not allow us to stratify for gear type. Furthermore, according to Caminas *et al*. (2006), calculating the CPUE based on gear type alone does not accurately reflect bycatch estimates.

Using known spatial distribution and abundance of sea turtles in the Benguela provided by published work and considering the variation in effort across the region, longitudinal variation in the number of incidentally caught sea turtles will exist. As sea turtle presence is considerably lower in the central and southern portions of the Benguela, we would expect the catch rate to be lower in these regions compared with the northern Benguela where sea turtle abundance is likely to be higher (Hughes *et al.* 1973, Carr and Carr 1991, Fretey 2001). Thus the catch rate from the South African data of 0.2 sea turtles per 1000 hooks may be appropriate for the southern and central Benguela (i.e. south of 15ºS). Based on this catch rate approximately 4 200 sea turtles are likely to be caught per annum in this region. Since no sea turtle bycatch data exists for pelagic longlining in the northern Benguela we do not have the same level of confidence in our estimate. However, sea turtle bycatch has been reported in artisanal and trawl fisheries operating off Angola (Afonso 1987, Afonso *et al*. unpublished, Ron unpublished). If the catch rate estimated for the Atlantic by Lewison *et al.* (2004) is applicable to this region, as many as 35 000 sea turtles could be caught per annum. Thus a total of approximately 39 200 sea turtles could be caught in the BCLME.

The catch rate reported for the South African pelagic longline fishery is generally lower than catch rates reported elsewhere in the world (Table II). This may be due to a lower abundance of sea turtles in the region and/or the result of an insufficient sample size to adequately assess sea turtle bycatch. This highlights the need for comprehensive data collection in the region. Similarly, low estimates of sea turtle bycatch reported by fishers are likely to only be an assessment of their perception and thus a minimum estimate.

Of the five species confirmed to occur in the Benguela, it is likely that loggerhead and leatherback turtles will contribute the highest proportion of bycatch in the mid and southern regions of the Benguela. These two species contribute 76% of the total sea turtle bycatch in the South African pelagic longline fishery which also operates north of the Namibian border (Fig. 2). Furthermore, the at-sea movements of leatherback turtles are becoming better understood and they are known to cover large distances in the Atlantic (Billes 2006). Locally, post-nesting leatherback females migrating from their breeding sites on the east coast of South Africa (Luschi *et al.* 2003) could potentially be caught by fishing operations in the Benguela. Similarly, leatherback turtles breeding on the west coast of Africa that undertake transatlantic migrations to South America (Billes and Fretey unpublished data) face the same threat. Also, both juvenile and adult loggerhead turtles are also known to travel great distances (Hawkes *et al.* 2006) and are frequently caught in longline fisheries globally (Spotila *et al.* 2000, Carreras *et al.* 2004, Lewison *et al.* 2004).

Olive ridley turtles are the most frequently recorded at-sea and on land in Angola (Hughes 1982, Carr and Carr 1991, Ron unpublished), therefore they are also expected to be caught in high numbers in this region. Although green turtles occur throughout the region, significant numbers are only likely to be caught in southern Angola, particularly on the Angolan-Namibian border where large juvenile and adult aggregations have been observed (Hughes *et al.* 1973, Hughes 1982). Hawksbill turtles are least likely to be caught in sizeable numbers as previous studies confirm no bycatch of this species in longline fisheries in South Africa (Petersen 2005), and infrequent sightings and no evidence of breeding sites of this species have been observed off the coast of Angola (Hughes 1982, Carr and Carr 1991).

In Angola, sea turtles are not only caught by industrial longliners as is the case for South Africa and Namibia, but also by coastal artisanal fisheries (e.g. gill nets, beach seines and longlines). The level of bycatch could not be quantified, but it is clear that turtle bycatch is widespread in coastal fishing communities. Consequently, the situation is a far more socio-economically complicated as the use of sea turtles is largely for subsistence and partially as a source of income. Future efforts to mitigate sea turtle bycatch could be achieved most effectively via a reduction in the use of coastal fishing nets adjacent to key nesting beaches during the nesting season (Pandav *et al.* 1997). However, as fishing is an important for for coastal communities livelihoods, a solution for sea turtle exploitation in Angola must be inextricably linked to poverty relief, and in particular to the development of sustainable alternative livelihoods (Hughes et al.1973, Hughes 1982, Ron unpublished). In Cabinda, some efforts were made in the past where a subsidy was given for the replacement of nets damaged by sea turtle entanglements, in exchange for the release of captured sea turtles, proving to be a highly successful form of mitigation.

What is of further concern for sea turtles in the BCLME is the threat by other fisheries such as the purse seine, shrimp trawl and pelagic trawl fisheries. Mortality has been documented in these fisheries in other regions (Hillestad *et al.* 1982, Magnuson *et al*. 1990, Pandav *et al.* 1997, Silvani *et al.* 1999, Zeeberg *et al.* 2006). However, the level of mortality caused by these fisheries in this region is less well understood. At present, pelagic purse seine and trawl fisheries targeting sardine *sardinella* spp and horse mackerel *Trachurus* spp respectively operate in South Africa, Namibia and Angola (FAO 2004b, Voges 2005) and could be impacting sea turtles. Global shrimp trawl fisheries have been shown to kill up to 55 000 sea turtles each year (Magnuson *et al.* 1990). Both South Africa and Angola have a trawl fishery targeting shrimps. While the fishery in South Africa is quite small, where only two vessels are active at present (Fennessy pers. comm.) operating outside of the Benguela current along the north coast of Kwazulu-Natal, the fishery in Angola has up to 50 active vessels operating annually (FAO 2004b) and thus could be capturing significant numbers of sea turtles. Moreover, there is an active gillnet fishery operating in close proximity to sea turtle nesting beaches in Angola which is likely to further impact sea turtles in the region (Bianchi et al. 1999, Fretey 2001).

In the past the sea turtle bycatch in fishing operations in the Benguela system has not been actively addressed by the three countries reviewed in this paper. Recently South Africa has included regulations in its longline fishing permits that now require vessels to carry a dehooker and a line cutter. Both Namibia and Angola have little or no protection against the variety of at-sea threats faced by sea turtles, and no sea turtle bycatch assessment work has been conducted in these two countries in the past. Be that as it may, all three countries have signed the Memoranda of Understanding concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa, but subsequently, little implementation of at-sea conservation measures has taken place. The United Nations 1995 Code of Conduct for Responsible Fisheries (FAO 2004a) provides internationally accepted guidelines for the development and implementation of national fisheries policies, including gear modification, new technologies and management of areas where fishery and sea turtle interactions are more severe. Suggested gear modifications include the replacement of J-hooks by circle hooks or squid bait with fish bait (Watson *et al.* 2003). Other suggested mitigation measures include setting the gear deeper than 40 m and reducing the soak time. As some sea turtles are alive on capture, fishers should be educated on the use of releasing tools and procedures. In cases when an unusually high catch of sea turtles occurs, the general “move on” rule can be applied. In conclusion the guidelines note that multinational efforts are needed immediately in areas such as education and training, active participation of fishers and fishing industries, collection of information and data, legal aspects and the need for review of the effectiveness of mitigation measures (FAO 2004a).

Furthermore, a substantial proportion of the effort in the BCLME is conducted by high seas fleets (89%) and a reduction of sea turtle bycatch in the national fleets of the three coastal states will not be sufficient to adequately reduce turtle sea bycatch in this region as a whole. It is therefore essential that regional fisheries management organisations such as ICCAT implement measures to address this issue and take into account the technical guidelines developed by the FAO (FAO 2004a). Thus far, ICCAT has adopted a resolution for the reduction of sea turtle mortality (Resolution 03-11) which encourages States to submit data on sea turtle interactions, release sea turtles alive wherever possible, and conduct research on mitigation measures. They have also encouraged states to include sea turtle bycatch experts attendance at its meetings (ICCAT 2003, 2004). It is however, the responsibility of each international fleet to implement mitigation measures that can reduce or eliminate sea turtle bycatch across fleets and basins.

The main issues that require attention and need addressing in the region as far as sea turtle bycatch is concerned is the lack of data in all fisheries throughout the region, although the pelagic longline sector should be highlighted a priority. The need for education and awareness is also critical to resolving this issue and should be targeted at fisheries observers, managers, compliance officers and the fishing industry. Further engagement with the industry is imperative as their involvement is vital to ensure the implementation of solutions. There is also a major need for further development and demonstration of mitigation measures to reduce sea turtle bycatch.

In conclusion, this study identifies the BCLME as an important region for sea turtle conservation, particularly in the north, where large numbers of sea turtles nest on the beaches of the Angolan coast and where a number of fisheries cumulatively could be impacting on populations. All five species occurring in the BLCME are of conservation concern and face the threat of extinction. Two of which, the hawksbill and leatherback turtles are critically endangered and thus even individual animals caught may contribute to the survival of these species.

5. References

AFONSO, E. C. 1987 - Contribution for Knowledge of the Sea Turtles Chelonidae of the Bay of Mussulo. Report of Apprenticeship for University Degree. Department of Biology , Sciences Faculty of Agostinho Neto University (UAN).

AFONSO, E. C., MORAIS, M. V. and C.M. ANDRADE unpublished - Evaluation of the status of the Sea Turtles along the Highway of Barra of Kwanza.

AGUILAR, R., MAS, J. and X. PASTOR 1995 - Impact of Spanish swordfish longline fisheries on the loggerhead sea turtle *Caretta caretta* population in the western Mediterranean. In: Richardson JI and Richardson TH (eds) Proceedings of the 12th Annual Workshop on Sea Turtle Biology and Conservation. NOAA Tech Mem NMFS-SEFSC **361:** 1–6

BIANCHI, G., CARPENTER, K.E., ROUX, J.-P., MOLLOY, F.J., BOYER, D. and H.J. BOYER 1999 – Sea Turtles. In *FAO species identification guide for fishery purposes. Field guide to the living marine resources of Namibia*, Carpenter, K.E. and T.R. Wasaff (Eds). Italy; Rome: 196-198

BILLES, A., FRETEY, J., VERHAGE, B., HUIJBREGTS, B., GIFFONI, B., PROSDOCIMI, L., ALBAREDA, D.A., GEORGES, J-Y. and M. TIWARI 2006 - First evidence of leatherback movement from Africa to South America. *Marine Turtle Newsletter* **111**: 13-14.

BRAVO, C. M., SHALEYLA, K.S., and X. VELEZ-ZUAZO 2006 - Impact of the Common Dolphin Fish Longline fishery on Sea Turtles along the Peruvian coast between 2003-2005. Abstracts of the 26th Annual Symposium on Sea Turtle Biology and Conservation, 3-8 April 2006, Island of Crete, Greece.

CAMIÑAS, J.A., BAEZ, J.C., VALEIRAS, X. and R. REAL 2006 – Differential loggerhead by-catch and direct mortality due to surface longlines according to boat strata and gear type. *Scientia Marina* **70(4)**: 661-665

CARR, T. and CARR, N. 1991 - Surveys of the sea turtles of Angola. *Biological Conservation* **58**: 19-29.

CARRERAS, C. CARDONA, L. and A. AGUILAR. 2004 - Incidental catch of the loggerhead turtle *Caretta caretta* Balearic Islands (western Mediterranean) *Biological Conservation* **117**: 321–329

CROWDER, L. 2000 - Leatherback's survival will depend on an international effort. *Nature* **405**: 881.

FAO 2004a - Code of Conduct for Responsible Fisheries. Implementation of the International Plan of Action for the Management of Fishing Capacity. Report presented at the Technical Consultation to Review Progress and Promote the Full Implementation of the IPOA to Prevent, Deter and Eliminate IUU Fishing and the IPOA for the Management of Fishing Capacity. Rome Italy, 24-29 June 2004. Available at ftp://ftp.fao.org

FAO 2004b - Fishery Country Profile: Angola. Available at: http://www.fao.org/fi/fcp/en/AGO/profile.htm

FRETEY, J. 2001 - Biogeography and Conservation of Marine Turtles of the Atlantic Coast of Africa/Biogéographie et conservation des tortues marines de la côte atlantique de l'Afrique. CMS Technical Series Publication No. 6, UNEP/CMS Secretariat, Bonn, Germany.

HAWKES, L.A., BRODERICK, A.C., COYNE, M.S., GODFREY, M.H., LOPEZ-JURADO, L-F., LOPEZ-SUAREZ, P., MERINO, S.E., VARO-CRUZ, N. and B.J. GODLEY 2006 - Phenotypically linked dichotomy in sea turtle foraging requires multiple conservation approaches. *Current Biology*. **16:** 990-995.

HUGHES, G.R. 1982 - Conservation of sea turtles in the Southern African region. In *Biology and Conservation of Sea Turtles* Bjorndal, K. (Ed.). Washington D.C.; Smithsonian Institution press: 397-404.

HUGHES, G.R., HUNTLEY, B. and WEARNE, D. 1973 - Conservation around the world: Sea turtles in Angola. *Biological Conservation* **5:** 58-59.

HUTCHINGS, L., PITCHER, G.C., PROBYN, T.A. and G.W. BAILEY 1995 - The chemical and biological consequences of coastal upwelling. In: Summerchanges, C.P., Emeis, K-C., Angel, M.V., Smith, R.L. and B. Zeitzschel (Eds) Upwelling in the Ocean: Modern Processes and Ancient Records. John Wiley and Sons Ltd: 65-81

INTERNATIONAL COMMISSION FOR THE CONSERVATION OF ATLANTIC TUNAS (ICCAT) 2006 - *Nominal catches of Tunas and tuna-like fish, by gear, region and flag in MS Access format*. Available at: www.ICCAT.es

IUCN 2006 - The IUCN Red List of Threatened Species. IUCN, Gland, Switzerland. www.redlist.org (accessed 18 May 2006).

KAMEZAKI, N., MATSUZAWA, K., ABE, O., ASAKAWA, H., FUJII, T., and K. GOTO. 2003 - Loggerhead turtles nesting in Japan. In: *Loggerhead Sea Turtles* (eds Bolten, A.B. and Witherington, B.E.). Smithsonian Institution Press, Washington, DC, pp. 210–217.

LEWISON, R.L. and L.B. CROWDER 2003 - Estimating fishery bycatch and effects on a vulnerable seabird population. *Ecol. Appl*. **13**: 743–753.

LEWISON R.L., FREEMAN, S.L. and L.B. CROWDER. 2004 - Quantifying the effects of fisheries on threatened species: the impacts of pelagic longlines on loggerhead and leatherback sea turtles. *Ecology letters* **7**: 221-231

LIMPUS, C.J. and D.J. LIMPUS 2003 - The loggerhead turtle, Caretta caretta, in the Equatorial and Southern Pacific Ocean: a species in decline. In *Loggerhead Sea Turtles* (eds Bolten, A.B. and Witherington, B.E.). Smithsonian Institution Press, Washington,DC, pp. 199–209.

LUSCHI, P. A. SALE, R. MENCACCI, G. R. HUGHES, J. R. E. LUTJEHARMS and F. PAPI 1 - Current transport of leatherback sea turtles (*Dermochelys coriacea*) in the ocean Proc. R. Soc. Lond. B (Suppl.) **270**: S129–S132

MAGNUSON, J. J., J. A. BJORNDAL, W. D. DUPAUL, G. L. GRAHAM, D. W. OWENS, C. H. PETERSON, P. C. H. PRITCHARD, J. I. RICHARDSON, G. E. SAUL, and C. W. WEST. 1990 - Decline of sea turtles: causes and prevention. National Research Council, National Academy Press, Washington, D.C., USA.

PANDAV, B., CHOUDHURY, B.C. and C.S. KAR 1997 - Mortality of olive ridley turtles *Lepidochelys olivacea* due to incidental capture in fishing nets along the Orissa coast, India. *Oryx* **31**: 32-36.

RON, T. unpublished - Preliminary marine turtle survey along the coastline of Angola – a periodic report, October-December 2002 - Submitted to UNDP-Angola and the Ministry of Urban Affairs and Environment of Angola.

SHANNON, L.V. and G. NELSON. 1996 – The Benguela: Large scale features and processes and system variability. In: Wefer, G. and G. Siedler, (Eds) South Atlantic Circulation: Past and Present. Springer Verlag. 163-210

SHANNON LV and M.J. O'TOOLE. 2003 - Sustainability of the Benguela: ex Africa simper aliquid novi. Published in *Large Marine Ecosystems of the World: Trends in Exploitation, Protection and Research*, G. Hempel and K. Sherman (Eds.) Elsevier B.V. 227-253.

SILVANI, L., GAZO, M., and A. AGUILAR 1999 - Spanish driftnet fishing and incidental catches in the western Mediterranean. *Biological Conservation* **90**: 79–85.

SPOTILA, J.R. 2004 - *Sea Turtles: A Complete Guide to Their Biology, Behavior, and Conservation*. The Johns Hopkins University Press, Maryland, US.

WITZELL, W.N. 1996 - The Incidental Capture of Sea Turtles by the US Pelagic Longline Fleet in the Western Atlantic Ocean. In: Williams, P., Anninos, P.J., Plotkin, P.T., Salvini, K.L. (Compilers), Pelagic Longline Fishery–Sea Turtle Interactions, Proceedings of an Industry, Academic and Government Experts, and Stakeholders Workshop, Silver Springs, Maryland, 24–25 May 1994. NOAA Tech. Memo. NMFS-OPR-**7**: 32–38

WITZELL, W.N. 1999 - Distribution and relative abundance of sea turtles caught incidentally by the U.S. pelagic longline fleet in the western North Atlantic Ocean, 1992–1995. Fisheries Bulletin **97**: 200–211.

YEUNG, C. 1999 - Estimates of marine mammal and marine turtle bycatch by the US Atlantic Pelagic Longline Fleet in 1998. NOAA Tech. Memo. NMFS–SEFSC **430**: 26.

YEUNG, C. 2001 - Estimates of Marine Mammal and Marine Turtle Bycatch by the US Atlantic Pelagic Longline Fleet in 1999–2000. NOAA Tech. Memo. NMFS–SEFSC **467:** 43

Sharks

The impact of longline fisheries on pelagic and demersal sharks in the Benguela Current Large Marine Ecosystem

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The Benguela Large Marine Ecosystem (BCLME) is utilised by 36 species of sharks that are listed as threatened. Sharks are taken incidentally as bycatch in non-directed fisheries and, in this paper, we attempt to describe and quantify for the first time the impact of longline fisheries on sharks in the BCLME. In the South African pelagic longline fishery, an average of 23.3 sharks retained per 1 000 hooks was recorded for the South African flagged vessels, an average of 12.4 sharks retrained per 1 000 hooks for the Asian flagged vessels. In the South African demersal fishery, an average catch rate of 10.4 sharks per 1 000 hooks was recorded. Thus, an overall number of approximately 415 000 sharks is estimated to have been caught in South African waters by longline fisheries during the study period. Namibian longline fisheries were estimated to kill approximately 85.3 sharks per 1 000 hooks in the pelagic longline fishery and 10.4 sharks per 1 000 hooks in the demersal longline fishery. The South African and Namibian longline fisheries are thus estimated to catch approximately 90 440 blue and 6 500 mako sharks each year. However, these are not the only fleets operating in the Benguela but limited data exist for distant water fleets and Angolan pelagic longline and artisanal line fisheries. Based on catch rates calculated from South African and Namibian observer data, and ICCAT effort data, we estimate a total of 1.1 million mako and 5.5 million blue sharks are killed per annum by all fleets operating in the BCLME.

Key words: *shark bycatch, pelagic and demersal longline fishing*

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1. Introduction

Many shark species are apex predators and occupy an important trophic position in marine ecosystems (Garcia and Majkowski 1990, Lewison *et al.* 2004, Megalofonou *et al.* 2005). Historically sharks were perceived to be of low-value and made minor contributions to the overall fisheries production of most nations (Barker and Schluessel 2005), mostly due to the high urea content of their meat (Cunningham-Day 2001). However, in recent years there has been an elevated demand for shark fin (Musick *et al*. 2000). Finning, the removal of the fin and subsequent discard of the body (Musick *et al.* 2000), now occurs more often than ever before and is unlikely to decrease unless drastic management measures are taken. Shark fins, besides being considered highly lucrative in many parts of the world, are also desirable due to the relatively little effort and storage required to obtain and keep them (Cunningham-Day 2001, Barker and Schluessel 2005). Although more than 150 countries trade in shark fin (Cunningham-Day 2001) this is not the sole reason for the depletion in shark numbers worldwide. Sharks are also taken incidentally as bycatch in non-directed fisheries and have been since the advent of the worldwide fishing industry (Musick *et al.* 2000, Cunningham-Day 2001, Beerkircher *et al.* 2002, Myers and Worm 2003). This has led to a growing global concern about shark conservation and management.

Many sharks have life histories that are characterised by slow growth, large adult body size, late reproduction, low fecundity, low natural mortality and a long lifespan when compared to teleost fish (Gruber *et al.* 2001, DFO 2002, Lewison *et al.* 2004, Megalofonou *et al*. 2005). This makes them very susceptible to population declines as a result of fishing impacts (Hoenig and Gruber 1990, Hurley 1998, Musick *et al.* 2000, Frisk *et al.* 2001).

In the past, little attention has been given to the research and management of sharks taken in fishing operations (Barker and Schluessel, 2005, Megalofonou *et al.* 2005) and as a result, basic knowledge about their biology, population dynamics, distribution and movements is limited.

The Benguela Current Large Marine Ecosystem (BCLME) is a highly productive upwelling system off the West coast of South Africa, Namibia and Angola (Hutchings *et al.* 1995, Cole 1999). The BCLME is utilised by 36 species of sharks that are listed as threatened according to IUCN criteria, and are impacted by fisheries' operation (cite IUCN website or relevant publication). Nineteen of these species are threatened due to bycatch, of which longline bycatch is a known threat to eight: the thresher shark *Alopias vulpinus*, great hammerhead *Sphyrna 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* (IUCN 2006). This paper describes the impact of longline fisheries operating in the BCLME on the sharks of this region.

Sharks are caught around the entire Southern African coast and by several fisheries sectors, including, longline, trawl, commercial line fish and the recreational fishery. This paper however, only focuses on the longline fishing impacts occurring within the BCLME, i.e. east of 0º, west of 20º E, north of 35º S and south of 5º S.

In Namibia, sharks were first commercially exploited at the beginning of the nineteenth century off Lüderitz in the south (Holtzhausen 2003), mainly for their high quality liver oil. Namibia has since been listed amongst the top ten shark exporters for 2004 (with 3.3% of the total world exports; Lack and Sant 2006) and, currently, four different fishery sectors (pelagic longline, demersal longline, demersal trawl and recreational) catch various shark species in Namibian waters, either as directed catch or bycatch (taken from Holtzhausen 2003).

The Angolan coast extends for approximately 1 500 km along the southeastern Atlantic, from 5º to 16º S, to the Kunene river mouth (de Lourdes Sardinha 2005). The Angolan longline fishery can be divided into artisanal coastal handline fishing and longlining by commercial fishing vessels. Angolan fisheries are not required to report on levels of bycatch and thus very little information is available.

In this paper we attempt to describe and quantify for the first time the impact of longline fisheries on sharks in the BCLME both as directed and incidental catch.

2. Methods

For the purposes of this paper, the BCLME region is defined, as west of 20º E, north of 35º S and south of 5º S. Shannon and O'Toole (2003) describe the eastern-most boundary of the BCLME as 27º E. However, fisheries in South Africa are generally managed on the 20º E longitude. The Regional Fisheries Management Organisations, such as the International Convention for the Conservation of Atlantic Tunas (ICCAT) and Indian Ocean Tuna Commission (IOTC), are also divided along this boundary.

At-sea collection of data

Data were collected by fisheries' observers' onboard pelagic longline vessels in South Africa and Namibia from 2000 to 2005 and 2002 to 2005 respectively. The data used includes pelagic and demersal shark bycatch information (species and number), gear (number of hooks) and operational information (time of setting and hauling, position etc) where available.

In South Africa and Namibia, trained observers identified all sharks that were caught, while at sea. In addition a specialised South African observer was used to collect pelagic shark bycatch in South Africa and Namibia during 2005. Note that only retained catches are recorded for Namibia and thus all estimates for this fleet will be a minimum estimate of total impact. No observer data is available from Angola.

Bycatch was reported as catch rates i.e. numbers of pelagic sharks caught per 1 000 hooks set. Seasons were defined as summer (December to February), autumn (March to May), winter (June to August) and spring (September to November). Chi-squared tests were used to compare effort between years and seasons for the time period.

Effort Data

Fishing effort and distribution data is available from observer reports and logsheets for both South African and Namibian fleets. An estimate of total shark bycatch for South African and Namibian fleets was calculated by summarising observer data by one degree grid squares in order to estimate a catch rate per grid square. There was only sufficient data to calculate catch rates for the two most commonly caught species, namely blue and mako sharks. Total effort obtained from the log sheets was then used to calculate the estimated total blue and mako catches per annum.

As we were not able to obtain fishing effort data from observer reports and vessel logsheets for longline fishing in Angola, the public domain data available on the ICCAT website (www.iccat.org) was used. These data are available at a five degree grid square resolution and were also used for other fleets operating throughout the BCLME. Average catch rates were calculated by averaging the above calculated one degree catch rates. Where this was not possible an average of catch rates in bordering grid squares was used. In this way, average catch rates per five degree grid squares were calculated and these were multiplied by the average annual effort per grid square over the time period 2000 to 2004.

3. Results

South Africa

<u>Pelagic longline fishery</u>

The South African pelagic longline fishery is essentially made up of two fleets, namely South African vessels targeting swordfish and Asian vessels targeting tuna species *Thunnus* spp. The South African fleet primarily uses the American longline system, which typically sets at night, has short branchlines (average 40m) and uses lightsticks. From 2000 to 2005, a total of 5 593 600 hooks were set at an annual average of 932 000 hooks. Eight percent or 447 000 hooks were set with fisheries observers onboard. Asian vessels (Japanese, Korean and Philippine vessels, using the Asian longline system and predominantly targeting Tuna) set a total of 278 900 hooks during the time period 2000 to 2005. A total of 26% or 71 800 hooks were observed.

An average catch rate of 23.3 sharks per 1 000 hooks was recorded for the South African pelagic longline fleet. With an average of 932 000 hooks being set each year, this fishery could kill approximately 21 750 sharks per year on average (Table 1). The most common species (85%) caught by South African vessels was the blue shark at some 18 550 and a rate of 19.9 sharks per 1 000 hooks per year. The second most commonly caught species was the mako shark (7.6%) at a catch rate of 1.8 sharks per hook or 1 650 sharks per year. The remaining 7.1% of the shark catch comprised of bronze whalers, thresher, oceanic whitetip, crocodile, probeagle, bigeye thresher, cookie cutter, dusky and hammerhead spp.

Table I: Shark bycatch composition from 2000 to 2005, by South African vessels

Shark species		**Observed catch**	**Catch rate (sharks/1000 hooks)**	**Estimated annual catch**	**Percentage composition**
Blue	*Prionace glauca*	8 901	19.9	18 550	85.3%
Mako	*Isurus* spp.	792	1.8	1 650	7.6%
Bronze Whaler	*Carcharhinus brachyurus*	293	0.7	610	2.8%
Thresher	*Alopias vulpinus*	139	0.3	290	1.3%
Oceanic Whitetip	*Carcharhinus longimanus*	125	0.3	260	1.2%
Crocodile	*Pseudocarcharias kamoharai*	90	0.2	190	0.9%
Porbeagle	*Lamna nasus*	61	0.1	130	0.6%
BigEye Thresher	*Alopias superciliosus*	27	0.1	60	0.3%
Cookie Cutter	*Isistius brasiliensis*	3	0.0	6	0.0%
Dusky	*Carcharhinus obscurus*	2	0.0	4	0.0%
Hammerhead	*Sphyrna spp.*	1	0.0	2	0.0%
Unidentified		2	0.0	4	0.0%
	Total sharks	**10 436**	**23.3**	**21 756**	**100%**

Bycatch rates of sharks reported by Asian vessels operating in South African waters was almost half that of the South African vessels (14.9 and 24.4 sharks per 1 000 hooks respectively), however this was not significant (t=1.5, df = 372, p=0.14), nor was the difference in species composition (Table II). At an average annual effort of 46 484 hooks, this fishery is estimated to catch about 575 sharks per year at a rate of 12.4 sharks per 1 000 hooks. Blue sharks were again the most commonly caught shark, comprising 83.8% of the total shark catch, at a rate of 10.4 blue sharks per 1 000 hooks as compared with 19.9 blue sharks caught per 1 000 hooks recorded by the South African vessels although this difference was not significant (t=1.3, df = 372, p=0.18). Mako sharks were the second most commonly caught species, making up 12.2% of the Asian catch, at a rate of 1.5 mako sharks per 1 000 hooks, which is similar to South African vessels (t=-0.67, df = 372, p=0.5). The remaining 4.1% was made up of thresher, porbeagle and crocodile sharks.

Table II: Shark bycatch composition from 2000 to 2005, by Asian vessels operating in the South African pelagic longline fishery

Shark species		**Observed catch**	**Catch rate (sharks/1000 hooks)**	**Estimated annual catch**	**Percentage composition**
Blue	*Prionace glauca*	744	10.4	500	83.8%
Mako	*Isurus* spp.	108	1.5	70	12.2%
Thresher	*Alopias vulpinus*	32	0.4	20	3.6%
Porbeagle	*Lamna nasus*	3	0.0	2	0.3%
Crocodile	*Pseudocarcharias kamoharai*	1	0.0	1	0.1%
	Total sharks	**888**	**12.4**	**593**	**100%**

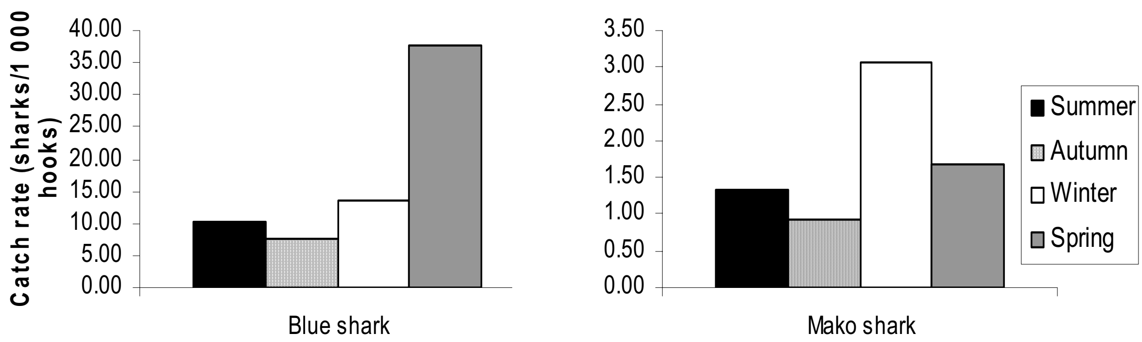

Fig. 1: Seasonal variation in blue and mako shark catch rates by all vessels operating in the South African pelagic longline fishery

Catch rates of blue sharks showed marked seasonal variation (χ^2 =4658, p<0.05, df = 3) with highest catch rates being recorded in spring (37.8 sharks per 1 000 hooks). No such trend was evident for mako sharks (χ^2 =204, p<0.05, df = 3) (Fig. 1).

Blue sharks were retained in 72%; released alive in 18%; discarded (dead) in 5% and unknown for the remaining 4% of cases. In 2000 and 2001, observers reported an average of 27.5% of discarded blue shark catches finned. In the case of mako sharks, most commonly the whole shark was retained (86%). 10% were released alive and 2% discarded. Observers did not record whether sharks were hauled onboard dead or alive.

Demersal longline fishery

The South African demersal longline fishery targets hake *Merluccius* spp and sets on average 7.2 million hooks per year (2000 to 2004). Approximately 4%, or 1.3 million hooks, were shot with a fisheries observer onboard.

Table III: Shark bycatch from 2000 to 2004, by South African vessels operating in the demersal pelagic longline fishery

Family	Species name		Observed catch	Catch rate (sharks/1000 hooks)	Estimated annual catch	Percentage composition
Squalidae	Black dogshark	Centroscyllium fabricii	387	0.29	10 560	3.3%
	Longnose dogshark	*Centroscyllium crepidater*	70	0.05	1 910	0.6%
	Shortnosed spiny dogshark	*Squalus megalops*	1	0.00	30	0.0%
	Shortspine spiny dogshark	*Squalus mitsukurii*	2,353	1.78	64 200	20.1%
	Spiny unidentified dogshark	*Squalus*	4,217	3.18	115 060	36.0%
	Shorttail lanternshark	*Etmopterus brachyurus*	15	0.01	410	0.1%
	Black lucifer shark	*Etmopterus lucifer*	7	0.01	190	0.1%
	unidentified Lanternshark	*Etmopterus*	34	0.03	930	0.3%
	unidentified dogshark		53	0.04	1 450	0.5%
		Sub-total	**7 137**	**5.39**	**194 740**	**61.0%**
Scyliorhinidae	Izak catshark	*Holohalaelurus regini*	719	0.54	19 620	6.1%
	Leopard catshark	*Poraderma pantherium*	222	0.17	6 060	1.9%
	Striped pajama catshark	*Poraderma africanum*	1	0.00	30	0.0%
	Tiger catshark	*Halaelurus natalensis*	2	0.00	60	0.0%
	Yellow spotted catshark	*Scyliorhnus capensis*	628	0.47	17 140	5.4%
	Puffadder shy shark	*Haploblpharus edwardsii*	632	0.48	17 250	5.4%
	unidentifed shy shark	*Haploblpharus*	313	0.24	8 540	2.7%
	unidentified catshark		216	0.16	5 900	1.8%
		Sub-total	**2 733**	**2.06**	**74 600**	**23.4%**
Triakidae	Houndshark	*Mustelus mustelus*	1	0.00	30	0.0%
	White spotted houndshark	*Mustelus palumbes*	1	0.00	30	0.0%
	Soupfin shark	*Galeorhinus galeus*	58	0.04	1 590	0.5%
		Sub-total	**60**	**0.05**	**1 650**	**0.5%**
Other sharks	Mako shark	*Isurus oxyrinchus*	45	0.03	1 230	0.4%
	Blue shark	*Prionace glauca*	433	0.33	11 810	3.7%
	St Josephs shark	*Callorhinus capensis*	6	0.00	160	0.1%
	unidentified shark		2,163	1.63	59 000	18.5%
		Sub-total	**2 647**	**2.00**	**70 970**	**22.6%**
Rajidae	Yellowspot skate	*Raja wallacai*	361	0.27	9 850	3.1%
	Slime skate	*Raja pullopunctata*	199	0.15	5 430	1.7%
	Biscuit skate	*Raja straeleni*	128	0.10	3 490	1.1%
	Roughbelly skate	*Raja springeri*	101	0.08	2 760	0.9%
	Spearnose skate	*Raja alba*	13	0.01	360	0.1%
	Smoothback skate	*Raja ravidula*	4	0.00	110	0.0%
	Munchkin skate	*Raja*	2	0.00	60	0.0%
	Roughnose legskate	*Cruriraja parcomaculata*	10	0.01	270	0.1%
	Unidentified skate		358	0.27	9 770	3.1%
		Sub-total	**1 176**	**0.89**	**32 100**	**10.1%**
		Grant total	**11 698**	**10.38**	**374 060**	**100.0%**

Shark bycatch was recorded at an average catch rate of 10.4 sharks per 1 000 hooks (Table III). Given an average annual fishing effort of 8.3 million hooks, we estimate that approximately 374 060 sharks and skates are caught in this fishery each year. A total of 18 species of shark and 8 species of skate have been recorded as bycatch in this fishery. Species from the family squalidae made up 61% of the total chondrichthyan catch at a rate of 5.4 per 1 000 hooks. The most common squalid caught was the shortspine spiny dogshark. It was estimated that an average of 194 740 dogshark were caught per year. The family scyliorhinidae, which includes the catsharks and shy sharks, make up 23.4% and were caught at a catch rate of 2.06 sharks per 1 000 hooks. Three species of the family triakidae were recorded caught and together they make up 0.5 % of chondricthyan bycatch. Skates comprise 10.1% and are caught at an average catch rate of 0.9 per 1 000 hooks, or approximately 32 100 per year.

Most skates, *Rajidae* (n=1 176), were caught in autumn (χ^2 =385, p<0.05, df = 3), whereas houndsharks *Triakidae* (n=60), catsharks *Schliorhinidae* (n=2 733) and dogsharks *Squalidae* (n=7 137) were caught in spring (Fig. 2). Spring catch rates for dogsharks (χ^2 =1604, p<0.05, df = 3) reach a maximum of 8.54 sharks per 1 000 hooks and 3.36 sharks per 1 000 hooks for catsharks (χ^2 =739, p<0.05, df = 3). Houndsharks (χ^2 =75.8, p<0.05, df = 3) also show their highest catch rate in spring (0.11 sharks per 1 000 hooks) whereas skates display a higher catch rate in autumn than in any other time of the year (1.56 sharks per 1 000 hooks).

Shark directed longline fishery

The shark directed longline fishery commenced in 1992 and is ongoing. From 1992 until the end of 2005 vessels operated under a shark longline licence and could target either pelagic or demersal sharks. Vessels targeting pelagic sharks used pelagic longline gear and thus primarily caught pelagic sharks, whereas vessels using demersal longline gear frequently used floats to make their gear more buoyant and thus caught a combination of demersal and pelagic species. Limited data exist for this fishery. Only three trips of observer data were available and thus we relied on landings data obtained from logsheets. A total of 57 vessels operated in this fishery over the time period although on average approximately 6 to 10 vessels were active in any one year. The total effort was 4 million hooks or 267 000 hooks per year. The most common species caught by number of individuals was the mako shark (38%), then blue shark (28%), followed by soupfin shark (18%), houndshark (8%), dogsharks (5%) and remaining 3% comprised of copper sharks, cowsharks, thresher, hammerheads and skates. We estimate that an average of 7 000 (372 to 26 626) individuals or 167 300 kg (7 011 to 656 116 kg) of mako shark and about 5 000 (205-18 977) or 54 000 kg (2 797-177 655 kg) of blue shark are caught each year in this fishery (note weights refer to landed weights). The three most commonly caught demersal sharks were soupfin, houndshark and dogsharks at an average of 3 295 (64-10 572) individuals or 24 042 kg (414-78 180 kg) per annum, 1 533 (0-11 427) individuals or 7 229 kg (0-53 263 kg) per annum, and 968 (0-9 707) or 1 142 kg (0-10 678 kg). Thus, an average of approximately 12 000 pelagic sharks and 5 800 demersal sharks are caught per year.

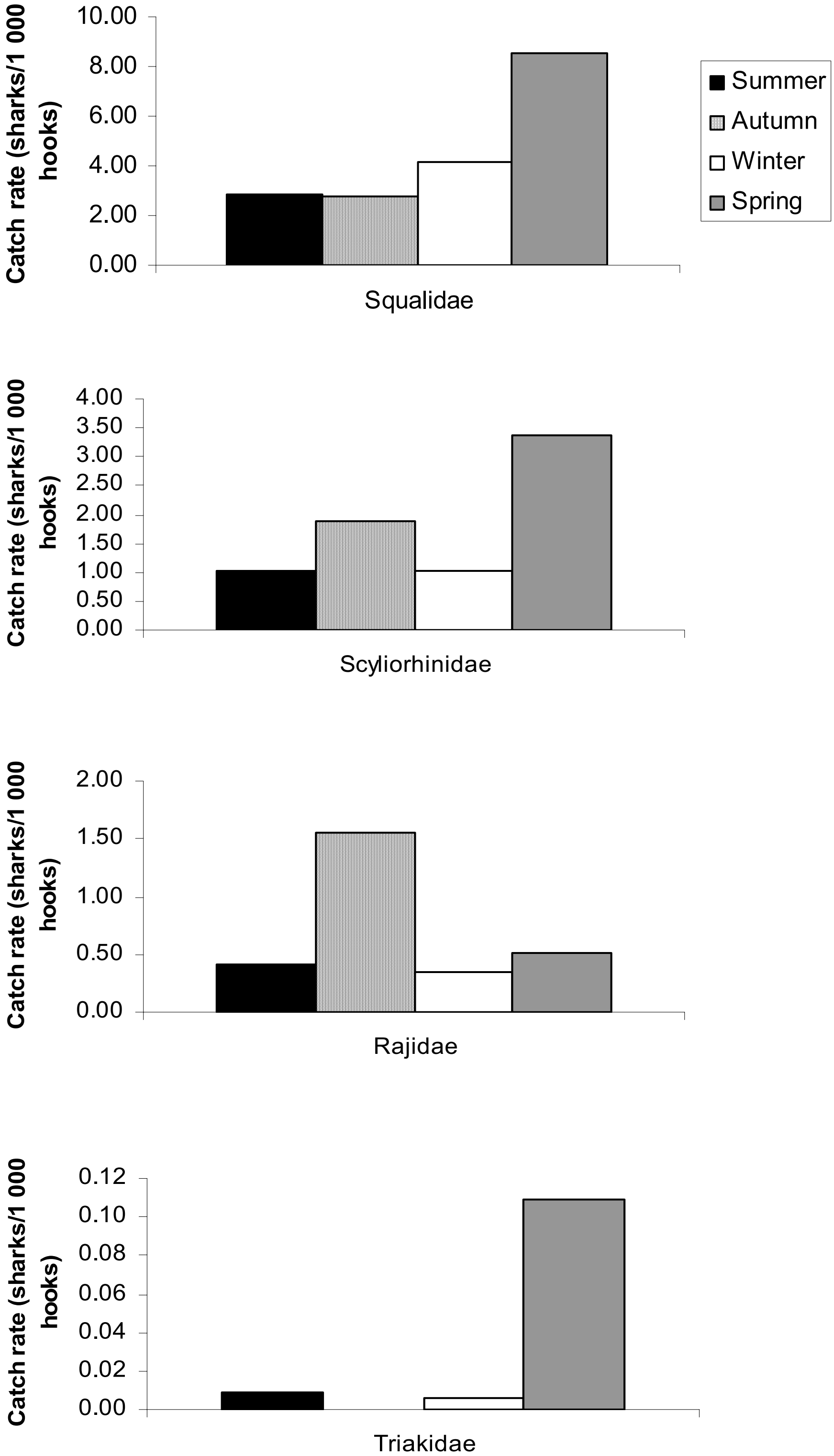

Fig. 2: Seasonal variation in chondrichthyan bycatch by demersal longliners operating in the South African fishery

By combining the estimates from the two fisheries we therefore estimate that approximately 415 000 sharks were caught each year in South African waters by longline fisheries during the study period. This estimate comprised of 34 000 pelagic sharks and 381 000 demersal sharks and rays.

Namibia

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 tuna, swordfish, blue and mako sharks (Voges 2005).

This fishery targets tuna species, swordfish and large pelagic sharks and sets on average 2.9 millions hooks per year and ranged between 2.5 and 3.5 million from 2002 to 2004. This fishery has 100% observer coverage and observers report 8 829 000 hooks were set by approximately 20 vessels during this time period.

An overall shark catch rate of 85.3 sharks per 1 000 hooks was recorded for this fishery. Based on this we estimate that this fishery caught approximately 251 000 sharks each year (Table IV). Blue sharks were the most commonly caught species (50.8%) with an estimated 127 480 animals caught each year at a rate of 43.3 sharks per 1 000 hooks. This was followed by mako (20 570 sharks or 8.2% of the total shark catch) and thresher sharks (17 540 sharks or 7% of the total shark catch).

Table IV: Species composition of shark bycatch in longline fisheries operating in Namibian waters from 2000 to 2004.

Shark species		**Observed catch**	**Catch rate (sharks/1000 hooks)**	**Estimated annual catch**	**Percentage composition**
Blue	*Prionace glauca*	382 445	43.3	127 480	50.8%
Mako	*Isurus spp.*	61 696	7.0	20 570	8.2%
Thresher	*Alopias vulpinus*	52 631	6.0	17 540	7.0%
Hammerhead	*Sphyrna spp.*	1 857	0.2	620	0.2%
Porbeagle	*Lamna nasus*	18	0.0	6	0.0%
Bigeye Thresher	*Alopias superciliosus*	4	0.0	1	0.0%
Unidentified		254 587	28.8	84 860	33.8%
	Total sharks	**753 238**	**85.3**	**251 077**	**100.0%**

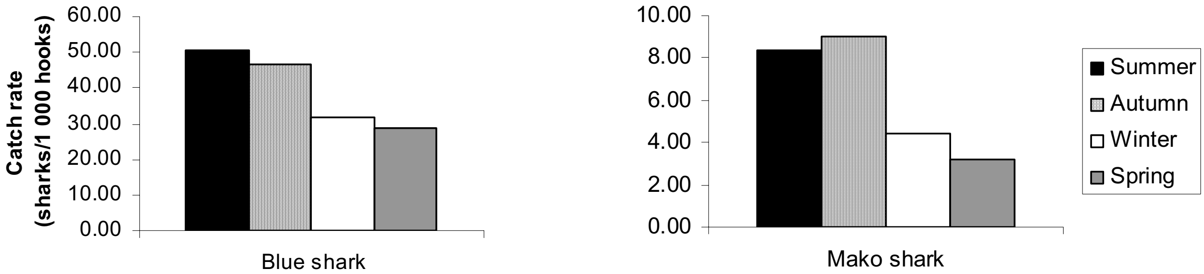

Fig. 3: Seasonal variation in Blue and Mako shark catch rates by all vessels operating in the Namibian pelagic longline fishery

Seasonal variations in catch rates were recorded for both blue (χ^2 =19 766, p<0.05, df = 3) and mako sharks (χ^2 =9 187, p<0.05, df = 3). Catch rates were the highest in summer for blue sharks (50.4 sharks per 1000 hooks) and highest in autumn for mako sharks (9.04 sharks per 1 000 hooks) (Fig. 3).

Demersal longline fishery

The Namibia demersal longline fishery targets hake *Merluccius* spp and comprises of approximately 25 vessels that operate out of both Walvis and Luderitz bays depending on the availability of fish. Fishing takes place mainly between the 19° S and 30° S, at sea depths of 200 to 600 m (average 330 m). Between 2000 and 2004, over 600 million hooks were set, resulting in an average of 104 million hooks or 6 040 sets per year. This fishery catches demersal sharks as bycatch although no data exists (Kainge pers. comm.). If catch rates are assumed to be the same as for the South African component of the BCLME (10.4 sharks per 1000 hooks), we estimate that approximately 1 081 600 sharks and skates could be killed each year.

Angola

Pelagic longline fishery

The pelagic longline fishery in Angolan waters targets tunas, swordfish and pelagic sharks. Between 1999 and 2003 on average 19 (18-23) industrial foreign flagged longline vessels operated in Angolan waters. This is however, not very representative of the true situation in Angolan waters since many vessels do not report their effort or catch to Angolan authorities. No specific shark information is available for Angola.

Artisanal line fishery

The Angolan artisanal subsistence handline fishery target line fish such as grouper (family serranidae), but occasionally catch sharks. Sampling surveys of these sharks at landing beaches were conducted during 2002 and 2003. A sample of 36 individuals was identified as shortnose spiny dogfish (36%), soupfin shark (33%), the smooth hammerhead shark (11%), the houndshark (6%), West African catshark (6%), thresher shark (6%) and the cookie cutter shark (3%). It was not possible to calculate catch rates for this fishery due to insufficient data.

Estimated overall impacts

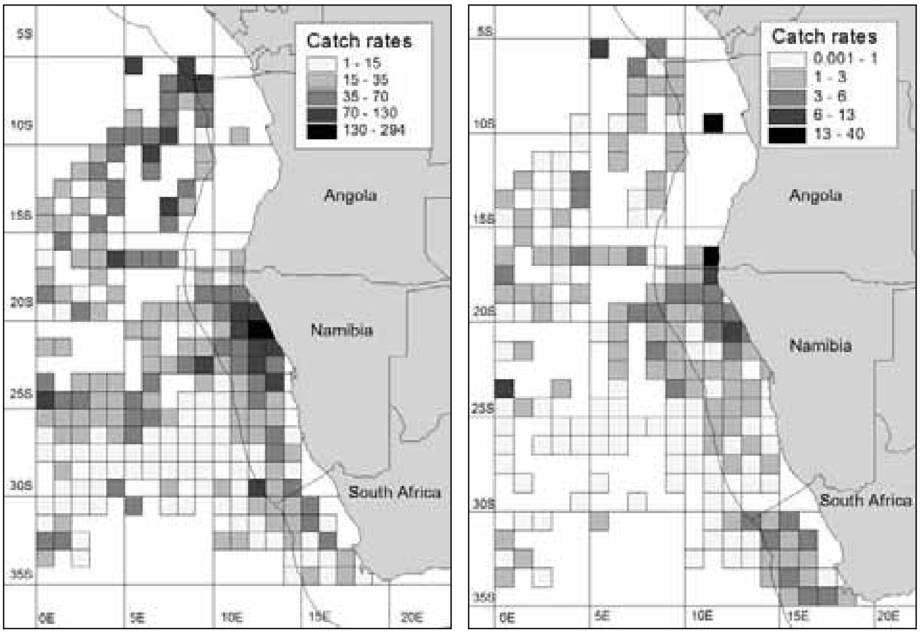

Fig. 4a & b: Distribution of a) blue and b) mako shark average annual catch rates from South African and Namibian observer data for 2000 to 2005 and 2002 to 2004 respectively, by 1^{o} grid squares.

Catch rates were by far the highest in the north (off Angola), reaching a maximum of 325 sharks per 1000 hooks. Catch rates varied between 0 and 294 blue sharks per 1000 hooks (Fig. 4a) and between 0 and 40 mako sharks per 1 000 hooks (Fig. 4 b). The catch rate of mako sharks is much higher inshore than offshore (Fig. 4b). No trend is observed in blue shark catch rates moving offshore.

Catch rates for Namibia and South Africa differed between year for both blue (χ^2 =111 635, $p<0.05$, df = 5 and χ^2 =6 966, $p<0.05$, df = 5 respectively) and mako sharks (χ^2 =34 411, $p<0.05$, df = 5 and χ^2 =224, $p<0.05$, df = 5). Catch rates for both blue and mako sharks caught in Namibia increased from 18.1 blue sharks per 1 000 hooks in 2002 to 98.9 blue sharks per 1 000 hooks in 2005 and 1.7 mako sharks per 1 000 hooks in 2002 and 20.9 mako sharks per 1 000 hooks in 2005. In South Africa there was an overall increase in CPUE for blue sharks from 14.1 per 1 000 hooks in 2000 to 26.3 per 1 000 hooks in 2005 (Fig. 5). There was no obvious trend in CPUE for mako sharks caught on South Africa's west coast.

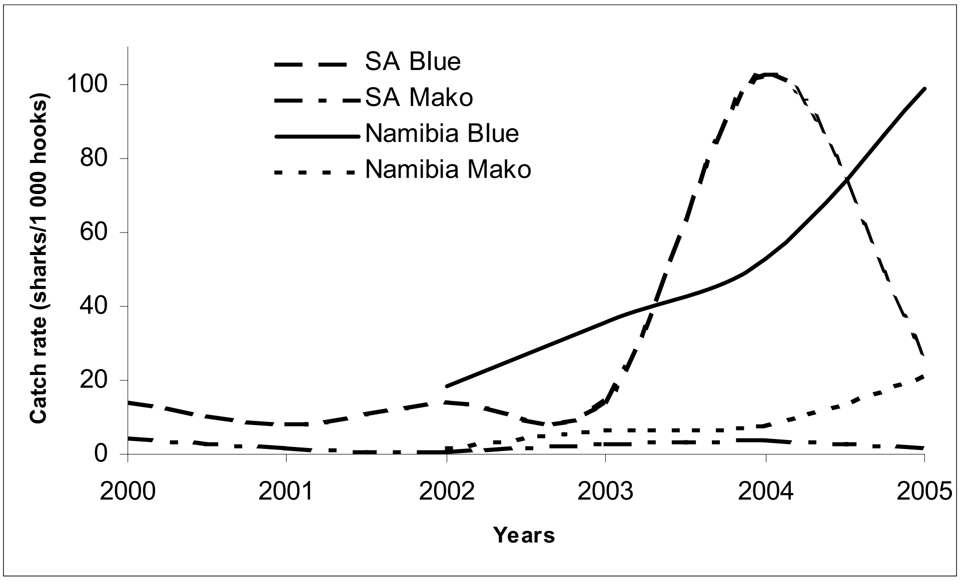

Fig.5: Trends in catch rates (sharks per 1 000 hooks) of blue and mako sharks by South African (2000-2005) and Namibian fleets (2002-2005)

Based on the catch rates described in the previous section, we estimate that the South African and Namibian longline fisheries catch approximately 90 440 blue and 6 500 mako sharks each year. However, these are not the only fleets operating in the Benguela. An analysis of the ICCAT data reveals nine nations fishing, of which South Africa and Namibia make up 1.0% and 2.1% of the total effort. Chinese Taipei and Japan make up 84% (46.4% and 37.4% respectively). The distribution of blue and mako shark bycatch in longline fisheries operating within the BCLME is given in Fig. 6 a and b respectively. Blue shark catches are the highest in the north, but no trend from inshore moving offshore. Mako sharks catch rates also decreased in the southerly direction, but were higher inshore than offshore. Based on these catch rates we calculate that approximately 1.1 million mako and 5.5 million blue sharks are killed per annum in the BCLME.

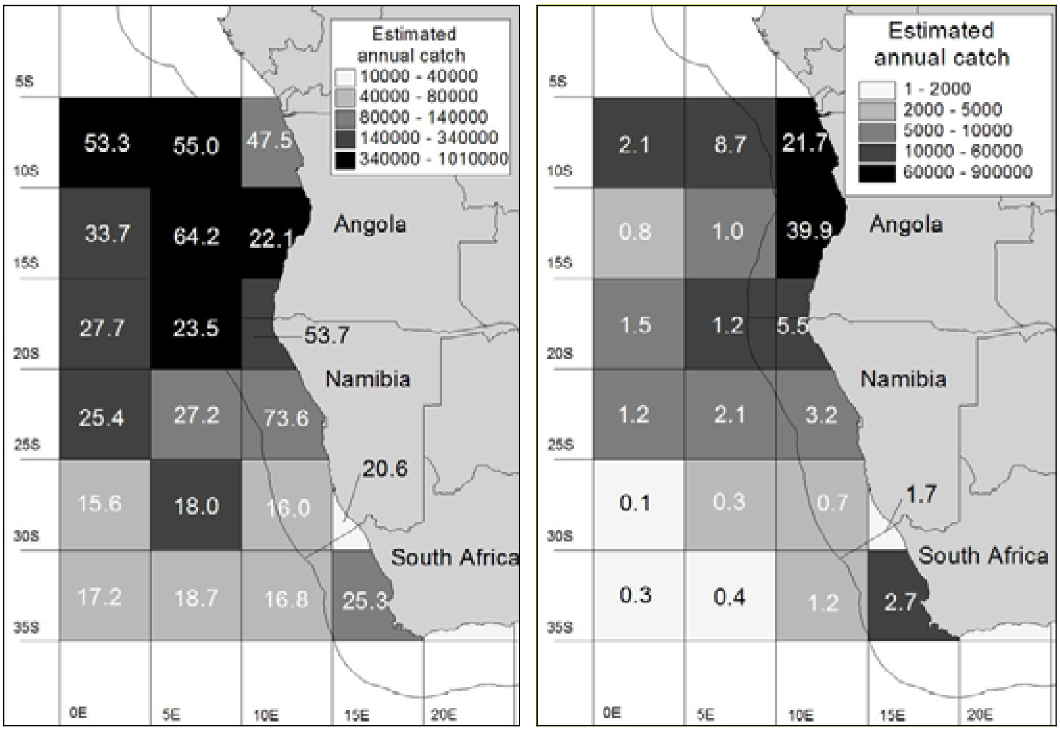

Fig. 6 a and b: Estimated annual total a) blue and b) mako shark catch with catch rates indicated in each 5 degree grid square

4. Discussion

This provides the first attempt to estimate the impact of longline fisheries in the BCLME, and suggests that about 6.6 million pelagic sharks (mostly blues and makos) and 1.2 million demersal sharks (mainly dogsharks) were caught each year for the period of this study. This amounts to a total of 7.8 million sharks and skates, or 234 000 tonnes (using the Bonfil 1994 conversion factor), killed per annum. Since in many cases only retained catches were recorded this is likely to be a minimum estimate. The estimated global annual shark bycatch at the end of the 1980s was approximately 260 000 to 300 000 tonnes, or 11.6–12.7 million sharks (Bonfil 1994), comprised predominantly of blue sharks.

By far, the species most often caught as bycatch and directed in South African, Namibian and Angolan waters alike is the blue shark. This appears to be consistent with what has been documented in many other parts of the world (Hurley 1998, DFO 2002). It is of particular concern that Namibian catches of blue sharks increased five-fold from 2002 to 2005 (with an almost doubling occurring between 2004 and 2005). Similarly, South Africa's catch rate of blue sharks in the BCLME almost doubled over the past 6 years. Mako shark catch rates also increased dramatically in Namibia with an over ten-fold increase from 2002 to 2005 and a three-fold increase from 2004 to 2005. The observed increases reflect an increase in the total retained catch and are likely to be the result of an increase in the Asian market's demand for shark fins (Prestowitz 1996). No trend in catch rate was observed in mako catches in South Africa. Both South Africa and Namibia's legislation requires both the fin and trunk of the shark to be landed. Moreover, it may also be that, as target stocks collapse or are seasonally unavailable; this fishery has begun retaining more of their shark bycatch (Rose 1998).

Blue sharks were predominantly caught during the spring in South Africa and during the summer off Namibia. Beerkircher *et al.* (2002) and Megalofonou *et al.* (2005) also report increased catch rates of blue sharks in spring in the swordfish and tuna fishery in the eastern Mediterranean Sea.

The catch rates of demersal sharks, whilst considerably lower than that of pelagic sharks raises particular concern for several reasons. Firstly, we believe that this estimate is likely to be conservative. While it is required that bycatch be retained long enough for the observer to identify and quantify it, cartilaginous fishes are frequently discarded at the hauling station of the vessel. As a result, they may not always be observed or accurately identified. Secondly, many of the species impacted upon by demersal longliners are also caught in other large fisheries such as the demersal trawl fishery. Thirdly, chances of survival of discarded cartilaginous fish species, both from longliners and trawlers, are unknown. Fourthly, many of the affected species are classified as 'threatened' or 'vulnerable' and little is known regarding the population status of many species (IUCN 2005). Finally, many species are endemic and thus have a limited range.

This report highlights the need for more informed management of sharks in the Benguela Current LME. Although little is known about the actual population size and trends of the affected shark species, the recent large increases in numbers of sharks being removed from this ecosystem is of concern not only because of possible impacts to the shark populations themselves, but also because of potential impacts that this may have on the health of the ecosystem itself (Stevens *et al.* 2000). We suggest that the management of shark catches in the Benguela is harmonised between the three countries and that removals are managed according to strict output controls. This will require that catches in the shark directed fisheries be conducted, along with Total Allowable Catches (TACs), according to management plans. For fisheries in which sharks are not target species, bycatch plans and limits should be developed. In developing such plans, special attention needs to be given to the life history traits of sharks, their important role in marine ecosystems and the current poor global conservation status.

The implementation of such management procedures will be dependent on reliable and representative data collected by well-trained fisheries observers. The quality of data collected can be improved for the entire region, but requires specific attention in Angola, and necessitates the refinement and development of specialised training programmes. Data is required on catch, effort and discards as well as information on the biological parameters of the shark species. Trade data may be a beneficial extra as, in the absence of comprehensible catch data, it may be a more reliable means of establishing actual catch levels (Lack and Sant 2006). Overall, effective management of shark fisheries necessitates that information be collected on a species basis.

Awareness should also be raised amongst the fishing industry about the conservation status of global shark populations, their important role in healthy marine ecosystems, and the importance of releasing unwanted sharks alive when possible.

Better compliance with existing regulations is also required. It is disconcerting that the finning of sharks is still reported by observers aboard South African pelagic longline vessels despite regulations to the contrary.

Despite the progress that South Africa has made in terms of monitoring fishing activities and collecting comprehensive and reliable fisheries' and bycatch data since 2000 through their observer program, a NPOA-Sharks has been drafted but not accepted as yet. Marine and Coastal Management (MCM) of the South African government has however made the recommendation for the closure of the pelagic shark directed fishery in South African waters but the matter is still unresolved (Petersen pers. comm.). At present, permit conditions allow for 10% of shark bycatch to be retained, although all live sharks should be released. Fins and trunks need to be landed together in ratios of 2% fin:live (whole body) weight or of 5% fin:dressed carcass weight (Lack and Sant 2006), as both measures are suitable for most large-finned species.

The Namibian NPOA-Sharks has been adopted (2003) but further research is still required. There is a need for improved quality of observer data. The recent BCLME-funded project established links between the industry, observers and researchers and these vital links need to be maintained and strengthened. No regulations exist in Namibia regarding shark bycatch in any fishery and this will also need to be addressed in management recommendations. At present, sharks may neither be discarded nor dumped. Future aspirations are for mitigation trials to take place and for management measures to be made a part of permit conditions. Industry has expressed a keen desire to be involved from the beginning.

Angola has not developed a NPOA-Sharks and this paper suggests that a thorough investigation may be necessary. As a signatory to the FAO, Angola is encouraged to formulate a NPOA-Sharks following the guidelines outlined in the International Plan of Action for reducing the bycatch of sharks in longline fisheries (IPOA-Sharks), which was developed by the FAO in 1999. Despite this however, a precautionary approach is still applicable.

As important as collaboration between Angola, Namibia and South Africa is in terms of consistent regulations, what is of higher importance is the specific nature of the shark fishing taking place within their own jurisdictions and the implementation of measures that are specific to their needs rather than a general approach (Lack and Sant 2006). This report has shown that the bycatch and directed catch of pelagic sharks in longline fishing operations operating within the BCLME is of high enough concern to take the necessary measures of reduction and, ultimately, of prevention.

5. References

BARKER, M. J. and V. SCHLEUSSEL. 2005 – managing global shark fisheries: suggestions for prioritising management strategies. *Aquatic Conserv:Mar. Freshw. Ecosyst.* **15**: 325 - 347

BEERKIRCHER, L. R., CORTES, E. and M. SHIVJI 2002 – Characteristics of shark bycatch observed on pelagic longlines off the Southeastern United States, 1992-2000. *Marine Fisheries Review*

BONFIL R. 1994 – Overview of world elasmobranch fisheries. FAO Fisheries Technical Paper 341, Food and Agriculture Organization of the United Nations, Rome.

COLE, J. 1999 – Environmental conditions, satellite imagery, and clupeoid recruitment in the northern Benguela upwelling system. *Fish. Oceanogr.* **8**: 1, 25 – 38

DFO, 2002 – Catch, Bycatch and Landings of Blue Shark in the Canadian Atlantic. DFO Science Fisheries Status Report 2002/02E

DUARTE, A. 2005 – Bycatch of threatened seabirds, sharks and turtles in long line fisheries in the BCLME – Angola Report BCLME Project BEHP/EEF/03/01, 02 Instituto de Desenvolvimento da Pesca Artesanal Rua José Pedro Tuca Nº 36/38 Cx. Postal 6776 Luanda – Angola

GRUBER, S. H., DE MARIGNAC, J. R. C. and J. M. HOENIG 2001 – Survival of Juvenile Lemon Sharks at Bimini, Bahamas, estimated by mark-depletion experiments. *Transactions of the Amercian Fisheries Society* **130**: 376 – 384

HOENIG, J. M. and S. H. GRUBER. 1990 – Life-history patterns in Elasmobranchs: Implications for fisheries management. *In:* Elasmobranchs as living resources: Advances in Biology, Ecology, Systematics, and the Status of the Fisheries, Pratt, H. L., Gruber, S. H. and T. Taniuchi (Eds.). NOAA Technical Report NMFS 90, United States Department of Commerce, Washington DC: 243 – 260

HOLTZHAUSEN, J. A. 2003 – The Namibian plan of action for the conservation and management of sharks (NPOA). Ministry of Fisheries and Marine Resources, Namibian Government.

HURLEY, P. C. F. 1998 – A review of the fishery for pelagic sharks in Atlantic Canada. *Fisheries Research* **39**: 107 – 113

HUTCHINGS, L., PITCHER, G.C., PROBYN, T.A. and G.W. BAILEY 1995 - The chemical and biological consequences of coastal upwelling. In: Summerchanges, C.P., Emeis, K-C., Angel, M.V., Smith, R.L. and B. Zeitzschel (Eds) Upwelling in the Ocean: Modern Processes and Ancient Records. John Wiley and Sons Ltd: 65-81

IUCN 2006 - The IUCN Red List of Threatened Species. IUCN, Gland, Switzerland. www.redlist.org (accessed 18 May 2006).

KITCHELL, J. F., ESSINGTON, T. E., BOGGS, C. H., SCHINDLER, D. E. and C. J. WALTERS 2002 – The role of sharks and longline fisheries in a pelagic ecosystem of the Central Pacific. *Ecosystems* **5**: 202 – 216

KROESE, M. and W. H. H. SAUER 1998 – Elasmobranch exploitation in Africa. *Marine and Freshwater Research* **49** (7): 573 – 577

LACK, M. and G. SANT 2006 – Confronting Shark Conservation Head On! TRAFFIC International, Cambridge, UK

MEGALOFONOU, P., DAMALAS, D. and C. YANNOPOULOS 2005 – Composition and abundance of pelagic shark by-catch in the eastern Mediterranean Sea. *Cybium* **29** (2): 135 – 140

MOLLOY, F. 2003 – Coastal environment. In *Namibia's Marine Environment*, Molloy and Reinikainen (Eds.). Directorate of Environmental Affairs of the Ministry of Environment and Tourism, Namibia: 25-29

MUSICK, J. A., BURGESS, G., CAILLIET, G., CAHMI, M. and S. FORDHAM. 2000 – Management of Sharks and their relatives (Elasmobranchii). *Fisheries* **25**: 9-13

PETERSEN, S. L. 2004 – Initial bycatch assessment: South Africa's domestic pelagic longline fishery, 2000-2003. BirdLife/WWF Responsible Fisheries Programme report

PRESTOWITZ C.V. 1996 – Asia rising: why Americ will prosper as Asias's economies boom. Journal of Asian Studies **55**: 973-975

ROSE D. 1998 – Shark fisheries and trade in the Americas, Volume 1: North America. TRAFFIC North America.

SARDINHA, M.d.L. 2005 – The Marine Environment in Angola: Threats and Methods of Management, *From A to B to Sea.* p.8-9

SAUER, W. H. H., HECHT, T. and BRITZ, P. J. 2002 – (Eds.). Economic and sectoral study (ESS) of the South African fishing industry. Volume 2: Fishery Profile. 308 p. Report for the Department of Environment Affairs and Tourism, Branch Marine and Coastal Management by Rhodes University. p.190 – 304

SIMPFENDORFER, C. A., HUETER, R. E., BERGMAN, U. and S. M. H. CONNETT. 2002 – Results of a fishery-independent survey for pelagic sharks in the western North Atlantic, 1977 – 1994. *Fisheries Research* **55**:175 – 192

STEVENS, J. D., BONFIL, R., DULVY, N. K., and WALKER, P. A. 2000 –. The effects of fishing on sharks, rays, and chimaeras (chondrichthyans), and the implications for marine ecosystems. – ICES Journal of Marine Science, **57**: 476–494

VOGES, L. 2005 – Bycatch of threatened seabirds, sharks and turtles in longline fisheries in the BCLME: an integrated approach initial assessment report of the longline fishery and the potential bycatch of seabirds, turtles and sharks for Namibia.

MITIGATION

Development of mitigation measures to reduce seabird mortality in longline fisheries in the Benguela Large Marine Ecosystem

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Reducing the incidental mortality of seabirds by longline fisheries can be achieved by either keeping birds away from baited hooks (e.g. bird-scaring or tori lines), reducing the time the hook is available to the birds (e.g. line weighting or line setting chutes), avoiding peak periods of bird foraging (e.g. night setting) or making the vessel or bait less attractive to the birds. This paper reviews mitigation measures tested and found effective as well as those still under refinement or tested and found ineffective. Furthermore, it suggests and recommends measures for future testing. To facilitate implementation of these measures it is vital that they are simple, easy to implement and cost effective. There is no one solution that will eliminate seabird bycatch, thus these measures should be used in combination. The choice may differ from fishery to fishery depending on gear configuration, preferred operation and species complexes involved. Thus far only South African fisheries regulations include seabird mitigation measures. We urge Namibian and Angolan authorities to implement the use of bird-scaring lines and a line sink rate of at least 0.3m/sec as a first step towards rectifying this.

Key words: *mitigation measures, seabird bycatch, pelagic and demersal longline fishing*

1. Introduction

Fishing operations attract and provide a feeding opportunity for a range of pelagic seabird species. Their incidental mortality on these vessels has been well documented and mounting evidence suggests that this is the leading cause of observed decreases amongst albatross and petrel populations (Gales 1998). It has been estimated that longline fisheries operating within the Benguela Current Large Marine Ecosystem incidentally catch approximately 34 000 birds (Petersen *et al.* 2006), 4 200 sea turtles (Honig *et al.* 2006) and 6.6 million sharks (5.5 million blue sharks *Prionacea glauca* and 1.1 million short-fin mako sharks *Isurus oxyrinchus* (Basson *et al.* 2006). Given their vulnerable biology these levels of bycatch are considered too high and require mitigation.

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Mitigation measures work by either keeping birds away from baited hooks (e.g. tori lines), reducing the time the hook is available to the birds (e.g. line weighting or line setting chutes), avoiding peak periods of bird foraging (e.g. night setting) or making vessels or bait less attractive to the birds. It is vital that these measures are simple, easy to implement and cost effective. This paper reviews mitigation measures a) tested and found effective, b) those still under refinement c) tested and found ineffective and d) those suggested for future testing.

2. Mitigation methods tested and effective

Setting lines at night

Albatrosses generally feed during the day, but lower numbers may forage at night. Therefore by setting lines between dusk and dawn, the danger of catching these birds is greatly reduced (Harper 1987). However the smaller petrels e.g. White-chinned Petrel, may feed at night and are therefore less protected (Harper 1987). Thus this measure in isolation is not sufficient to adequately reduce seabird bycatch. Seabirds will be especially vulnerable on clear, bright nights such as those during full moon periods.

Gilman *et al.* (2005) showed a 97-100% reduction in the capture of Laysan *Phoebastria immutabilis* and Black-footed *Phoebastria nigripes* Albatrosses in the Hawaiin longline fishery and Klaer and Polacheck (1998) a 91% reduction in the capture of all seabird species in the Japanese pelagic longline fishery when setting took place at night as opposed to during the day. In a study conducted in South African waters, it was found that the pelagic longline fishery, which sets a high proportion of their sets during daylight, catch approximately 0.2 birds per 1000 hooks while the demersal longline fishery which sets their lines primarily at night only catch 0.04 birds per 1000 hooks. This difference can in part be accounted for by the difference in setting time (Petersen *et al*. 2006). There is further evidence from a pilot study conducted in Namibia which revealed higher catches of 0.3 birds per 1000 hooks between full and half moon compared to no birds caught during between quarter and new moon periods (Goren 2007).

Current longline fisheries regulations in South Africa require all vessels to set their lines between nautical dusk and dawn. There are no such regulations in the Namibian and Angolan longline fisheries however, the hake demersal sector typically set at night.

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 a maximum depth of 67 m (Weimerskirch and Sagar 1996). By maximising the rate at which the longline sinks, you will minimise the time the hook is within the reach of the birds, and thus reduce the chance of birds being drowned.

Various "line weighting" regimes have been investigated and proposed for demersal and pelagic longlining (Brothers *et al.* 2001, Anderson and Mcardle 2002, Robertson *et al.* 2003, Moreno *et al.* 2006, Honig and Petersen 2006). Although the gear will be configured according to the particular fishery, a line sink rate of 0.3 m/s is recommended. This sink rate 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 (150 m).

<u>Demersal longline fishing</u>

Demersal longline vessels fishing for Patagonian Toothfish are required by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) regulations to achieve a line sink rate of at least 0.3 m/sec. This is done by attaching 8.5 kg weights every 40 m or 6 kg weights every 20 m on the line. Autoliners are recommended to attach a 5 kg weight every 50-60 m and vessels using an integrated weighted line must achieve a sink rate of 0.2 m/s (CCALMR 2005).

This fishery also requires vessels to conduct line sink rate trials on each fishing trip in non-territorial waters using either time-depth recorders (TDRs) or the "bottle test". Details of these tests may be found on the CCAMLR website (www.ccamlr.org). Each vessel has to demonstrate that its line sinks at the prescribed rate before it may commence fishing activities.

Line sink rate trials have been conducted in demersal longline fisheries (Robertson *et al.* 2003, Moreno *et al.* 2006). However, no studies have trialled line sink rates using the locally adapted Spanish longline method currently used in South Africa and Namibia i.e. concrete weights. Consequently no line weighting regime for demersal longline vessels targeting hake, have as yet been prescribed. However, according to South African hake longline fishery regulations vessels are required to achieve a line sink rate of 0.3 m/sec. Studies are underway to establish gear configuration requirements that will allow for this rate to be achieved while not compromising fishing efficiency. The current weighting regime employed by these vessels in South African waters places on average a 6 kg weight approximately every 100 m (Honig and Petersen 2005). Early results suggest that only the portion of the line where weights are placed reach the optimal rate of 0.3 m/s. The portion of line between weights and dropper lines sink at a much slower rate (Honig and Petersen 2005) (Fig. 1).

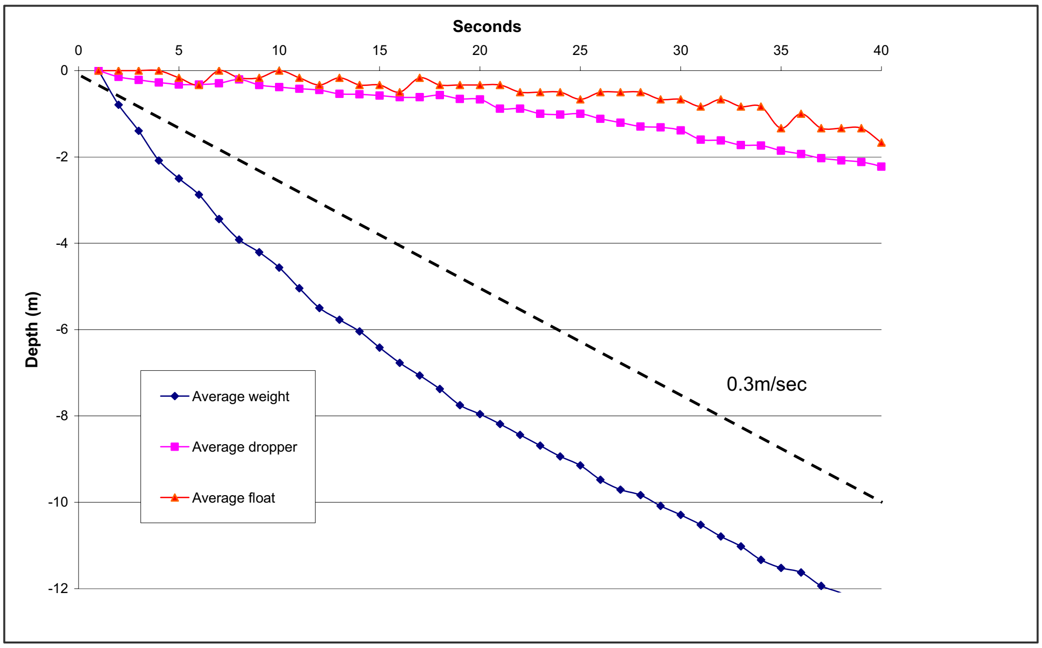

Fig.1: Average line sink rates achieved by weights, droppers and floats by South African demersal longliners (adapted from Honig and Petersen 2005).

No weighting regime or line sink rate requirements are stipulated in the Namibian longline fishing permits. Goren (2007) reports that a portion of the vessels use a similar gear configuration to the South African vessels, however a number of vessels use weights of a lower mass (average 3 kg) and spaced even further apart. Under this regime line sink rates are likely to be substantially slower and are cause for concern (Goren 2007).

Pelagic longline fishing

At present there are no prescribed weighting regimes to achieve optimal line sink rates in the pelagic longline fishery targeting tuna *Thunnus* spp. and swordfish *Xiphias gladius*. According to South African fishery regulations, vessels are required to achieve a line sink rate of 0.3 m/sec but studies are underway to establish gear configuration requirements that will allow for this rate to be achieved while not compromising the fishing efficiency (Honig and Petersen 2005). TDRs have been deployed on pelagic vessels in South African waters and preliminary findings suggest that the use of two 60 gram swivels (total 120 gram) on the branchline, 3.6 m from the baited hook will result in optimal line sink rates (Honig and Petersen 2005) (Fig. 2).

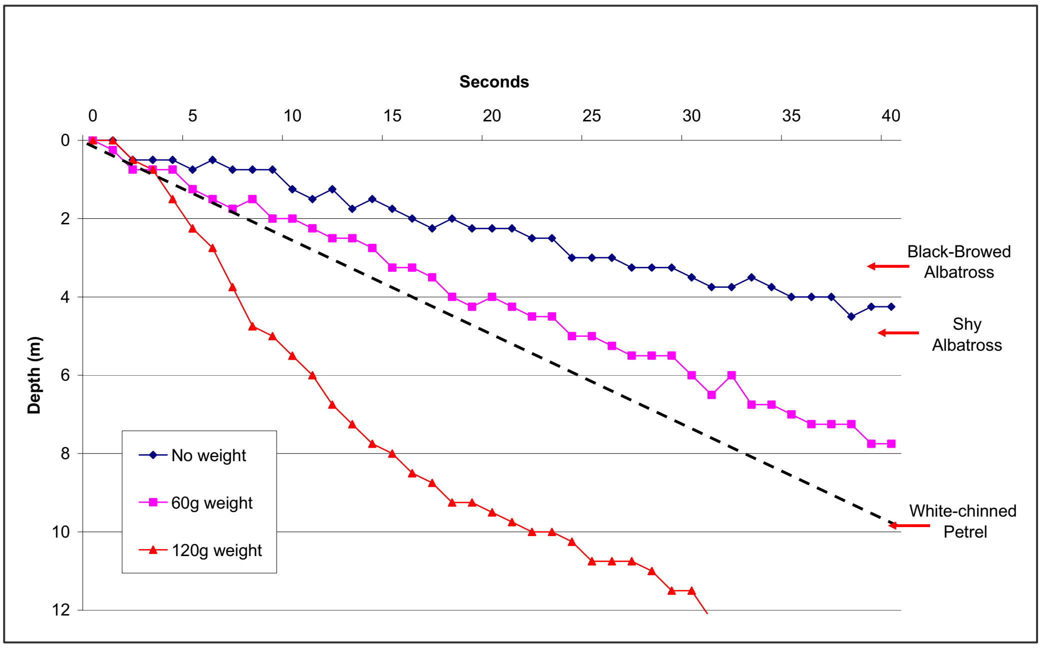

Fig. 2: Line sink rates of pelagic longliners under three different weighting regimes (no weight, one 60 g weight and two 60 g weight (i.e. 120 g) 3.6 m from the hook (adapted from Honig and Petersen 2005).
* maximum dive depths of most vulnerable species depicted on right hand side of figure.

Similar studies have been conducted in pelagic longline fisheries operating off New Zealand (Anderson and Mcardle 2002) and Australia (Brothers *et al.* 2001). These studies found that during normal line setting using unweighted branchlines a considerable proportion of hooks were within the known diving range of a number of seabirds frequenting these vessels (Brothers *et al.* 2001, Anderson and Mcardle 2002). The addition of a 60 g swivel weight within 1-2 m of the hook attained a line sink rate of 0.45 m/s. This results in the hook being out of the reach of most seabirds, excluding Sooty Shearwaters, after 30 seconds (it was estimated that the bird-scaring or *tori* line provided protection for 29.3 sec) (Anderson and Mcardle 2002). Brothers *et al.* (2001) found that the heavier the weight, and the closer it is to the hook, the more rapidly it will sink. In this study sink rates of 0.26 m/s to 0.30 m/s were attained using either an 80g weight within 3m of the hook, or a 40g weight at the hook. However, for such line weighting regimes to be effective in reducing seabird bycatch, they need to be deployed in conjunction with an effective bird scaring or *tori* line.

"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 fishing lines are being set. The streamers are designed to cover the point where the bait enters the water and distracts foraging birds from taking the baited hooks. The system works well for surface feeding birds, however, diving birds can still dive down to the bait outside of the effective area of the streamers. Still, this method has been demonstrated to reduce bycatch rates by up to 96% (Brothers *et al* 1999(a)). Mc Namara *et al*. (1999) showed a 79% reduction in the capture of Laysan and Black-footed Albatrosses in Hawaii. However the success depends on design and setting conditions as well as crew willingness and input.

Specifications

A number of trials were conducted in South African waters and produced the following specifications as a guideline for a best-design. These specifications have been included in South African fishing permit regulations. A bird-scaring line should achieve at least 150 m aerial coverage. It needs to be attached to the vessel at least 7 m above sea level, be at least 150 m long, have at least 28 paired streamers spaced 5 m apart (starting 10 m astern the vessel) and have sufficient drag (e.g. buoy, road cone or sea-anchor) (Fig.3). The bird-scaring line must be deployed on the windward side of the main line, unless two streamers are used, in which case they must be deployed on either side of the main line.

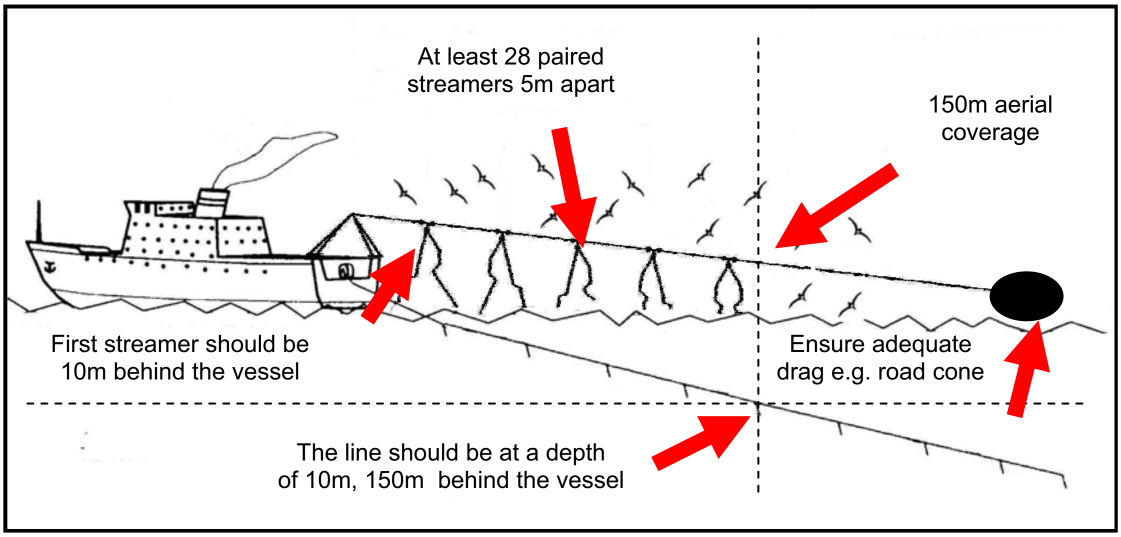

Fig. 3: Bird-scaring line and longline sink rate specifications

What makes an effective bird-scaring line?

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. 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.

Streamers can be made from plastic strapping or PVC tubing. They should be a bright colour, preferably red. Streamers shall be placed at least 5 m intervals 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.

Once a bird-scaring line is operating at its full height, a "lazy line" may be attached and tied off at a convenient point on the stern. This 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 the gear enters the water. By attaching 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 or on the windward side of the line.

It is important that the bird-scaring line is easy to use. To save space it can be stored on 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 buoys are thrown into the water may also prevent them from becoming snagged.

Frozen versus thawed bait

Thawed baits sink more rapidly than frozen baits. In experiments conducted on Japanese pelagic longliners, Brothers *et al* (1998) found that on average 1.1 birds per 1000 hooks were caught using frozen bait, compared to 0.6 birds per 1000 hooks using partly thawed and 0.3 birds per 1000 hooks using thawed bait demonstrating the effectiveness of this measure.

Current South African fisheries regulations require that all bait be thawed and where necessary, the swim bladder punctured to ensure the rapid sinking of bait. To our knowledge no such regulations exist in Namibian and Angolan fisheries.

Offal management

Albatrosses and petrels are opportunistic scavengers and fishing vessels processing at sea and discarding offal provide a feeding opportunity for these birds (Ryan and Moloney 1988). Therefore by minimising or eliminating discards seabirds will not be attracted to fishing vessels. Seabirds are most at risk of being caught during setting (Brothers *et al.* 1999a) therefore discarding should not take place during this time. If discarding is necessary during hauling, crew should be instructed to do so on the opposite side thereby reducing the risk of capture to the birds.

Current fisheries regulations for South African longline fisheries require vessels to dump offal on the opposite side of the vessel from that on which lines are hauled and no dumping of offal may take place during setting. Namibian fisheries regulations prohibit dumping of offal.

3. Other methods still under refinement

Underwater setting chute

Baited hooks may be set below the surface using a funnel fitted to the stern of the vessel, which guides the line directly from the vessel to below the water surface (Ryan and Watkins 2002). The system still requires refinement and is not widely used. A South African toothfish vessel used this system in 1998-2000 with some success, indicating its potential use (Ryan and Watkins 2002). At present funnels are designed mainly for a single line system however, investigations are underway to modify the system to accommodate the double line system. Gilman *et al.* (2005) demonstrated a 100% reduction in seabird bycatch levels in the Hawaiian pelagic longline fishery although later demonstrated less success. There have been serious problems with its effectiveness reported especially when entanglements occur and cause the line to lie on the surface for extended periods of time (Gilman *et al.* 2002), resulting in higher than normal mortalities of seabirds.

Underwater setting capsule

This method is similar to the underwater setting chute. In this case, baited hooks are deployed in a capsule attached to a cable, which is designed to open at a depth of 5-10 m and release the baited hook (Brothers *et al*. 2000). As with the underwater setting chute, line entanglements have been reported to occur. Further testing and modification is underway (Kreutz pers. comm.).

Side setting

This method requires the line to be set from the side of the vessel resulting in hooks sinking by the time they reach the stern of the vessel. This method was tested in combination with 60 g weights and a “bird curtain” (pole out the side with streamers) in the Hawaiian pelagic longline fishery and found to reduce the incidental mortality of Laysan and Black-footed Albatrosses up to 100% (Gilman *et al.* 2003). This method is currently employed in the Hawaiian and Australian pelagic longline fleet (Gilman *et al.* 2003). It needs wider testing in a number of localities with other species complexes (e.g. deeper diving species).

Fish oil

This method won the WWF "Smart Gear" award in 2005 for the most innovative idea to reduce seabird mortality. It has been tested in the Spanish and New Zealand demersal longline and some success has been demonstrated. Fish oil is released on the surface of the water during setting and has been shown to reduce seabird activity in the vicinity of the vessel (www.wwf.org).

4. Methods tested and found ineffective

Live bait

The concept of using live versus dead bait was investigated. It was thought that live fish would actively swim down from the surface. Observations suggest that fish may also swim to surface and thus be ineffective as a mitigation method. Brothers *et al.* (1999b) compared catch rates of live versus dead bait and found little evidence of a reduction in seabird catch rates.

Dyed baits

Dying baits blue so that they are less visible to seabirds was investigated as a measure to reduce seabird deaths. A number of studies were conducted and reported mixed successes (Gliman *et al.* 2003, 2005). Gliman *et al.* (2003) found a 95% reduction in mortality of Laysan and Black-Footed Albatrosses in Hawaii, but in a later study they found it less successful (63% reduction) than side-setting. At this stage this method is not practically feasible as there is no commercially available dye and it is a rather messy job (Gilman *et al.* 2005).

5. Future possibilities

Hook design

It has been suggested that hook designs (J-hooks, circle-hooks) have differing influences on seabird bycatch rate (Borneo workshop report 2005). However, little or no work to investigate this has been conducted to date.

6. Conclusion

There is no one magic solution, but rather a suite of measures that should be used in combination to mitigate seabird bycatch. The choice may differ from fishery to fishery depending gear configuration, preferred operation and species complexes involved. Fisheries regulations in South Africa addresses seabird bycatch, however two issues remain unresolved. Firstly, line sink rate trials need to be completed in order to advise on appropriate measures in this regard. Secondly, implementation of these regulations has been poor and requires improved enforcement. At present no such regulations exist for fisheries operating in Namibia and Angola. As a minimum we recommend the use of night setting, bird-scaring lines and a weighting regime that will ensure the gear sinks at a rate of at least 0.3m/sec in these fisheries.

7. References

ANDERSON, S. and B. MCARDLE. 2002 – Sink rate of baited hooks during deployment of a pelagic longline from a New Zealand fishing vessel. *New Zealand Journal of Marine and Freshwater Research.* **36**: 185-195.

BASSON, J. and PETERSEN S.L. 2006 – The impact of longline fisheries on pelagic and demersal sharks in the Benguela Current Large Marine Ecosystem. WWF South Africa report series-2007/marine001.

BROTHERS, N.P., COOPER, J. and S. LOKKENBORG. 1999(a) – The incidental catch of seabirds by longline fisheries: worldwide review and technical guidelines for mitigation. FAO *Fish. Circ*. **937**: 1-100.

BROTHERS, N.P., GALES, R. and T. REID. 1999(b) – The influence of environmental variables and mitigation measures on seabird catch rates in the Japanese tuna longline fishery within the Australian Fishing Zone, 1991–1995, *Biological Conservation* **88**: 85–101.

BROTHERS, N.P., J. COOPER, and S. LOKKEBORG. 1998 – The Incidental Catch of Seabirds by Longline Fisheries: Worldwide Review and Technical Guidelines for Mitigation. Preliminary Version. FAO Fisheries Circular No. 937. Food and Agriculture Organization of the United Nations, Rome. pp 99.

BROTHERS, N., CHAFFREY, D., and T. REID. 2000 - Final Report. Performance Assessment and Performance Improvement of Two Underwater Line Setting Devices for Avoidance Underwater Setting Chute and Seabird Bycatch in the Hawaii Longline Tuna Fishery Page 49 of Seabird Interactions in Pelagic Lonline Fisheries. ARF Project R2000/0469 Australian Fisheries Management Authority and Environment Australia: Canberra, Australia. pp 19.

BROTHERS, N.P., ROSEMARY, G. and T. REID. 2001 – The effect of line weighting on the sink rate of pelagic tuna longline hooks, and it's potential for minimising seabird mortalities. Nature Conservation Branch, Department of Primary Industries, Water and Environment, Tasmania. Unpublished report.

CCAMLR 2005 - Conservation Measure 25-02: Minimisation of the incidental mortality of seabirds in the course of longline fishing or longline fishing research in the Convention Area. Available at: www.ccaml.org

GALES, R. 1998 – Albatross populations: status and threats. In: *Albatross Biology and Conservation*. Robertson, G. and R. Gales (eds). Chipping Norton, NSW. Surrey Beatty and Sons. pp 20-25.

GILMAN, E., BROTHERS, N., KOBAYASHI, D., MARTIN, S., COOK, J., RAY, J., CHING, G. and B. WOODS. 2003 – Performance Assessment of Underwater Setting Chutes, Side Setting, and Blue-Dyed Bait to Minimize Seabird Mortality in Hawaii Pelagic Longline Tuna and Swordfish Fisheries. Final Report. National Audubon Society, Hawaii Longline Association, U.S. National Marine Fisheries Service Pacific Islands Science Center, U.S. Western Pacific Regional Fishery Management Council: Honolulu, HI, USA.

GILMAN, E., C.H. BOGGS, N. BROTHERS, D., MARTIN, S., COOK, J., RAY, J., CHING, G. and B. WOODS 2002 - Performance Assessment of an Underwater Setting Chute to Minimize Seabird Mortality in the Hawaii Pelagic Longline Tuna Fishery. Final Report. National Audubon Society, Hawaii Longline Association, U.S. National Marine Fisheries Service Pacific Islands Science Center, U.S. Western Pacific Regional Fishery Management Council: Honolulu, HI, USA.

GILMAN, E., BROTHERS N.P. and D. KOBAYASHI. 2005 – Principles and approaches to abate seabird bycatch in longline fisheries. *Fish and Fisheries* **6**: 35-49.

GOREN, M. 2007 – Seabird By-catch in the Namibia Hake longline fishery: a first assessment. Albatross Task Force Report. BirdLife South Africa, South Africa.

HARPER, P.C. 1987 – Feeding Behaviour and other notes on 20 species of Procellariiformes at sea. *Notornis* **34**: 169-192.

HONIG, M. and S.L. PETERSEN. 2005 **–** An investigation of mitigation methods to abate bycatch of vulnerable species in the hake longline fishery. A BirdLife Report. BirdLife South Africa, South Africa.

HONIG, M. and S.L. PETERSEN 2006 – The impact of longline fisheries on sea turtles in the Benguela Current Large Marine Ecosystem. WWF South Africa report series-2007/marine001

KLAER, N. and T. POLACHECK. 1998 – The influence of environmental factors and mitigation measures on bycatch rates of seabirds by Japanese longline fishing vessels in the Australian region, *Emu l* **98**: 305-316.

MC NAMARA, B., TORRE, L. and G. KAAIALII. 1999 – Hawaii Longline Seabird Mortality Mitigation Project. Western Pacific Regional Fishery Management Council: Honolulu, HI, USA.

MORENO, C.A., ARATA, J.A., RUBILAR, P., HUCKE-GAETE, R. and G. ROBERTSON. 2006 – Artisanal longline fisheries in Southern Chile: lessons to be learned to avoid seabird mortality. *Biological Conservation* **127**:27-36.

PETERSEN, S.L., HONIG, M. and NEL, D.C. 2006 – The impact of longline fisheries on seabirds in the Benguela Current Large Marine Ecosystem. WWF South Africa report series-2007/marine001

PRINCE, P.A., HUIN, N. and H. WEIMERSKIRSH. 1994 – Diving depths of albatrosses. *Antarctic Science.* **6**: 353-354.

ROBERTSON, G., MOE, E., HAUGEN, R. and B. WIEKECKE. 2003 – How fast do demersal longlines sink? *Fisheries Research* **62**: 385-388.

RYAN, P.G. and C.L. MOLONEY. 1988 - Effect of trawling on bird and seal distributions in the southern Benguela region. *Mar. Ecol. Prog. Ser*. **45**: 1-11.

RYAN, P.G. and B.P. WATKINS. 2002 – Reducing incidental mortality of seabirds with an underwater longline setting funnel. *Biological Conservation*. **104**: 127-131.

WEIMERSKIRSH, H. and P.M. SAGAR. 1996 – Diving depths of sooty shearwaters *Puffinus griseus. Ibis* **138**: 786-794.

POLICY

Reducing vulnerable bycatch in longline fisheries operating in the Benguela Current Large Marine Ecosystem: Implications for policy, management and research

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Globally, the last decade has witnessed a strong resolve to reduce the incidental mortality of seabird, turtles and sharks. This has manifested itself in a variety of recent policy developments both from a species conservation point of view (mostly under the Convention on Migratory Species) as well as from a fisheries management point of view (led in part by the FAO, as well as certain regional fisheries organisations). These developments set the scene for national implementation within the three coastal states of the Benguela Large Marine Ecosystem, namely South Africa, Namibia and Angola. South Africa's commitment to address these issues is largely reflected in recent amendments to fisheries policy and permit conditions that now require the use of mitigation measures. However, adequate implementation of these measures is still lacking in most instances. Efforts in South Africa need to focus on raising awareness, compliance, and bringing interested and affected parties together to identify solutions in a participatory manner. In Namibia, no legislation exists to reduce the bycatch of seabirds, turtles or sharks. There is also limited information to adequately assess the scale of the threat to these species. In Namibia, immediate efforts should be focused completing adequate assessments, and amending fisheries policy and regulations to require the use of known mitigation measures. In Angola, our knowledge of the nature and scale of fisheries impacts is still scant, although, this report points to the fact that impacts are potentially significant and warrant further investigation. Of particular concern was the impact of the artisanal fishery. In Angola, immediate effort needs to go into the development of a robust observer scheme to be able to quantify these impacts and develop well planned responses based on this. Finally, the newly formed Interim Benguela Current Commission (IBCC) can play a critical role in both the harmonisation of policy and legislation, as well as facilitation of knowledge and expertise exchange, in the region.

Key words: *bycatch, pelagic and demersal longline fishing, marine policy, Benguela*

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1. Introduction

Historically, fisheries have been managed primarily in terms of their impact on target catches. More recently there has been a global shift towards a more holistic Ecosystem Approach to Fisheries (EAF) management (FAO 2003). This approach considers fisheries impacts on the ecosystem in totality. Impacts include those on both the target and non-target species (bycatch), as well as impacts on food webs (e.g. through the removal of predators, prey species) and marine habitat modification (e.g. damage to benthic habitat) (Cochrane *et al.* 2004, Shannon *et al.* 2004).

Ecosystem impacts of the longline fishing technique include the incidental mortality to several vulnerable species. It has been estimated that that up to 300 000 seabirds are killed globally each year by long-line vessels leading to the concerning levels of population declines for several species, especially populations of albatrosses and petrels (Croxall and Gales 1998, Nel *et al.* 2002, BirdLife International 2005). More recently it has become evident that biologically-significant levels of incidental mortality is not restricted to seabirds, but affect a suite of K-selected species, including turtles (Chaloupka and Limpus 2001, Watson 2003, Carreras *et al.* 2004) and sharks (Coelho *et al.* 2003, Megalofonou *et al.* 2005). Lewison *et al.* 2004 estimated that 200 000 loggerheads and 50 000 leatherbacks are caught per annum globally. There is general agreement that fishing mortality is threatening the survival of seabirds (Croxall and Gales 1998) and turtles (Spotila *et al.* 2000) and good progress has been made in the identifying mitigation measures thereof. In most cases fishers do not want to catch seabirds and turtles. The exception being some subsistence and artisanal fishing communities, where seabirds and turtles are caught to supplement their diet or for cultural practises.

However, this is not the case for sharks because many species have a market value both for their flesh and fins. Globally few studies have focused on sharks and as a result, they are the group we understand the least and which lack appropriate management measures (Barker and Schluessel 2005).

Two longline fisheries operating within the Benguela Current Large Marine Ecosystem have been identified to be impacting marine megafauna such as seabirds, sea turtles and sharks, namely the demersal longline fishery operating in Namibia and South Africa and the pelagic longline fishery operating throughout the BCLME. It has been estimated that approximately 34 000 birds (Petersen *et al.* 2006), 40 000 sea turtles (Honig *et al.* 2006) and 6.6 million sharks (5.5 million blue sharks *Prionacea glauca* and 1.1 million short-fin mako sharks *Isurus oxyrinchus*) (Basson *et al.* 2006) are killed per year in the Benguela Current. This accounts for approximately 10% of global seabird bycatch and 15-22% of global turtle bycatch. Given their vulnerable biology these levels of bycatch are considered too high and require mitigation.

This paper reviews current policy and legislation, highlights research needs and comments on management measures required to address this issue in the Benguela Current Large Marine Ecosystem.

2. Current legislation and policy

International

The concept of an ecosystem approach to fisheries has been widely accepted as a preferred manner of managing fisheries and is entrenched in various international legal instruments and policy statements. This is perhaps most aptly illustrated in the 2002 World Summit on Sustainable Development (held in Johannesburg, South Africa and attended by both Namibia and Angola) Plan of Implementation, which urged states to apply an Ecosystem Approach to Fisheries by 2010 (UN 2002).

The 1982 United Nations Convention on the Law of the Sea (UNCLOS) is the principle global legal instrument governing the management of our oceans. With 150 ratifications (www.un.org) this agreement has been widely accepted as customary international law. Although UNCLOS does not explicitly refer to an ecosystem approach to fisheries in its text, it does require states to consider the effect of fishing activities on "species associated with or dependent upon harvested species with a view to maintaining or restoring population of such associated or dependent species above levels at which reproduction may become seriously threatened" (Article 61, paragraph 4). South Africa ratified UNCLOS in 1997, Namibia in 1983 and Angola in 1990.

The more recent UN Fish Stocks Agreement[1] (UNFSA) of 1995, developed under the auspices of UNCLOS, is more explicit in its endorsement of an EAF. It requires member States to "…minimize…catch of non-target species, both fish and non-fish species … and impacts on associated or dependent species, in particular endangered species, though measures including, to the extent practicable, the development and use of selective, environmentally safe and cost-effective fishing gear and techniques" (Article 5). Both Namibia and South Africa are members of the UNFSA. This Agreement is important in the context of this paper due to the fact that several species targeted by means of longlines within the EEZ's of South Africa, Namibia and Angola are in fact straddling and/or highly migratory species (tunas, swordfish and sharks). The UNFSA asserts that coastal States and States fishing for straddling stocks and highly migratory species in the adjacent areas have a "duty to co-operate for the purpose of achieving compatible measures in respect of such stocks."(Article 7, paragraph 2).

[1] Full name: Agreement for the implementation of the provisions of the UN Law of the Sea Convention relating to the conservation and management of straddling fish stocks and highly migratory fish stocks. Also referred to as the Straddling Stocks Convention.

In 1995 the Food and Agriculture Organisation of the United Nations (FAO) adopted a Code of Conduct for Responsible Fisheries (http://www.fao.org/fi). This code explicitly endorses an ecosystem approach to fisheries management and considers the integrity of the entire ecosystem and promotes the development of gear and techniques which maintain biodiversity and conserve vulnerable populations. Moreover, it advocates minimising waste, catch of non-target species and impacts on associated or dependent species. The code, although not legally binding, provides internationally accepted guidelines for the development and implementation of national fisheries policies, including the use of species selective gear. Namibia, Angola and South Africa are signatories to the Code of Conduct.

The FAO has further endorsed the need to reduce bycatch of vulnerable species through the development of International Plans of Action (IPOA's) for both seabirds and sharks. Under this process individual countries are required to develop National Plans of Action (NPOA's) that demonstrate the measures that individual countries will take to reduce impacts to these vulnerable suites of species. The NPOA-seabirds is an undertaking aimed at reducing mortalities of seabirds in longline fishing to insignificant levels and the NPOA sharks was developed as a result of the increasing commercial and bycatch takes of pelagic shark species, and the awareness of the vulnerability of these apex predators to fishing.

The Convention for Migratory Species (CMS) has recognised that migratory species are particularly vulnerable to bycatch in fisheries and require cohesive international efforts to curb these impacts. In this regard, the CMS has been instrumental in developing international Agreements and Memoranda of Understanding (MOU's) that specifically address the issue of bycatch of seabirds and sea turtles. These include the 2002 Agreement on the Conservation of Albatrosses and Petrels (ACAP). South Africa was instrumental in the development of this agreement and was a founder signatory. Namibia attended the first Meeting of Parties in Hobart, Tasmania in November 2004, but has not as yet signed the agreement. The (1999) MOU concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa was also developed under the CMS and has been ratified by South Africa, Angola and Namibia. The primary objective of this MOU is to conserve sea turtles throughout their breeding cycle (i.e. both on land and at sea). This MOU is still in its infancy and has not as yet become fully active.

Regional

Regional fisheries management organisations which overlap with the Benguela Current are the International Convention for the Conservation of Atlantic Tunas (ICCAT) and the South East Atlantic Fisheries Organisation (SEAFO). ICCAT, which came into force in 1969, is responsible for the management of tuna and billfish fisheries throughout the Atlantic. ICCAT's mandate covers tuna and tuna-like species, though the Scientific Committee has interpreted this as including a responsibility for collecting data on catches of sharks and other fishes. Recently resolutions addressing seabird, sea turtle and shark bycatch have been adopted. Resolutions and recommendations on sharks were adopted in 2001 (Resolution 01-11), 2003 (Resolution 03-10) and 2004 (Recommendation 04-10). These resolutions recognize the vulnerability of the shark species and request members to submit shark catch, effort and discard data, and to encourage fishers to release live sharks wherever possible. Resolution 03-10 required members to implement a NPOA-Sharks, and instructed the Bycatch Subcommittee to undertake stock assessments of shark species (porbeagle, blue and shortfin mako). The assessment was completed in 2004, although poor confidence in the results was reported due to a lack of data (ICCAT 2004b). The most recent recommendation on sharks reiterates these requests and further requests members to conduct research to identify shark nursery areas and to identify measures to reduce shark bycatch. A seabird resolution was adopted in 2002 (Resolution 02-14) after initial proposals in 2001 and 2002. This resolution encourages members to collect data on seabird interactions, urges members to implement NPOA-seabirds, and resolves that the Scientific Committee will report to the Commission on the impact of incidental mortality on seabirds 'when feasible and appropriate'. ICCAT's resolution for the reduction of sea turtle mortality (Resolution 03-11, tabled by US, Brazil, Japan and Canada) encourages States to submit data on sea turtle interactions, release sea turtles alive wherever possible, and conduct research on mitigation measures. While the resolutions on sharks, sea turtles and seabirds represent positive developments, it must be noted that none include a commitment from ICCAT to reduce bycatch, to undertake research on bycatch mitigation measures, or to implement mitigation measures. The Scientific Committee has encouraged members to include experts on sea turtles and seabirds at its meetings (ICCAT 2003b, 2004b), and in 2003 and 2004 the Scientific Committee made a recommendation to the Commission that ICCAT hire a bycatch coordinator (ICCAT 2004b, ICCAT 2004a). ICCAT also has a bycatch sub-committee which addresses bycatch issues.

The Convention on the Conservation and Management of Fisheries Resources in the South East Atlantic Ocean or SEAFO which came into force in April 2003 is responsible for managing fisheries operating on the high seas in the Southeast Atlantic (FAO Statistical Area 47). The application of an ecosystem approach is a cornerstone of the guiding principles (Article 3 c, d, e and f) of this modern convention. Namibia was a founder member, along with the European Community and Norway.[2] South Africa and Angola signed the convention on 14 August 2001. The convention includes a plan for a regional observer programme with seabird bycatch including data collection protocols as well as a regional enforcement system that will include both port and at-sea inspection (SEAFO 2001). SEAFO will manage non-tuna fish stocks, such as alfonsino, orange roughy, armourhead, wreck fish, deepwater hake and red crab. At present longline fisheries managed under this agreement are negligible.

Just recently South Africa, Angola and Namibia signed an agreement to formally establish the Interim Benguela Current Commission (IBCC), allowing for greater harmonisation of

[2] Current members are Namibia, Norway, Angola and the European Union. South Africa is expected to join in 2007 once its ratification procedures have been completed.

management of marine resources between the national jurisdictions of the three counties within the LME. The institutional structures of the IBCC include an Ecosystem Advisory Committee that will advise the Commission on the "ecological sustainable use" of the BCLME. The Interim Benguela Current Commission is the culmination of over 10 years of shared efforts by scientists from Angola, Namibia and South Africa.

National

South Africa

In South Africa, the principle Act guiding the utilization of marine resources is the Marine Living Resources Act (18) of 1998. This Act explicitly endorses the concept of "ecological sustainable development" and recognizes the need to "protect the ecosystem as a whole, including species which are not targeted for exploitation..." (Section 2a and e) as its guiding principles. Furthermore, in the General Policy on the Allocation and Management of Long Term Commercial Rights (2005), the South African government commits itself to "implementing an Ecosystem Approach to Fisheries Management by 2010".

The South African policy on seabirds, seal and shorebirds (2004) commits the government to adopt "plans of action to reduce the incidental mortality of seabirds and seals caused by fishing operations". A National Plan of Action for Reducing the Incidental Mortality of Seabirds in Longline Fisheries (NPOA-seabirds) has been drafted, but not as yet adopted. A National Plan of Action for the conservation and management of sharks (NPOA-sharks) has also been developed. The South African government is in the process of developing a policy for the conservation and management of sea turtles. This policy, although it is in draft form, considers sea turtle bycatch in longline fisheries.

Various measures to mitigate bycatch of vulnerable species have been included in permit conditions of longline fisheries. For seabirds, these include: a) The vessel should have onboard an approved bird-scaring line (tori line), which must be flown during setting of each longline. b) Offal dumping shall take place on the opposite side of the vessel from that on which lines are hauled. No dumping of offal may take place during setting c) Deck lighting should be kept to a minimum, without compromising safety. All deck lights should be shaded in such a way that the beam is directed down towards the deck. d) All bait must be appropriately thawed, and where necessary, the swim bladder punctured to ensure rapid sinking of bait. e) All birds caught alive on the haul should be released. f) Observers on board shall bring back whole specimens of all seabirds killed during longline fishing operations. g) For pelagic vessels: both the main line and branch lines (snood) must be properly weighted to ensure optimal sinking rates (approximately 0.3 m/sec or to reach a depth of 10m, 150m behind the vessel) and for demersal vessels: vessels using the Spanish method of longline fishing (double line) should release weights before line tension occurs. Weights of at least 8.5 kg mass, spaced at intervals of no more than 40 m, or weights of at least 6 kg mass spaced at intervals of no more than 20 m are recommended. h) Demersal longliners must set their lines at night only (i.e. during the hours of darkness between the times of nautical twilight).

At present longline fisheries in South Africa are required to release sea turtles caught and are encouraged to have a turtle dehooker and line cutter onboard. Mitigation measures for sharks include a) the use of stainless steel hooks and wire leaders (trace) are prohibited. b) *Chondrichthians* may not exceed 10% (by dressed weight) of the total catch (dressed weight) of the targeted species per trip. c) Fins may be removed only from sharks that are retained onboard and both the fins and trunks must be landed together. The maximum weight of fins landed or retained onboard shall not exceed 5 % of the total dressed weight of sharks retained onboard or landed.

Namibia

In Namibia, the principle legislation guiding fisheries management is the Marine Resources Act No. 27 of 2000. This Act's primary objective is to "provide for the conservation of the marine ecosystem and the responsible utilization, conservation, protection and promotion of marine resources on a sustainable basis; for that purpose to provide for the exercise of control over marine resources; and to provide for matters connected therewith." The Marine Resources Act (MRA) governs the allocation and duration of fishing rights. Additionally, broader fisheries policy is determined according to Namibia's National Development Plans (NDP's). The most recent policy document in this respect, *Towards Responsible Development and Management of the Marine Resources Sector*, was last updated in August 2004. Namibia is in the process of developing an NPOA-seabirds and NPOA-sharks. The NPOA-seabirds calls for a thorough assessment of seabird bycatch and if found to be unacceptably high mitigation will be implemented. At present no seabird or sea turtle mitigation measures are a condition of longline fisheries in Namibia. All dead sharks caught must be landed.

Angola

The principle act determining utilization of marine resources in Angola is the '*Lei dos Reicursos Biologicos Aquaticos*' or Aquatic Biological Resources Act of 2004, which represents a full revision of Angola's fisheries legislation. This new Act provides a comprehensive set of laws and reflects the Angolan Government's policies regarding environmental protection and the sustainable use of its resources. It takes account of Angola's international obligations according to the SADC Fisheries Protocol, UNCLOS and the Convention on Biological Diversity (CBD). Thus the principles of sustainable development, responsible fishing, an ecosystem approach to fisheries (EAF), optimal conservation and use of aquatic biological resources, as well as precautionary - , user-pays - , prevention - , and polluter pays principles are incorporated.[3] The Act illustrates an attempt

[3] See for example Article 6(3).

to harmonise various separate pieces of legislation governing Angola's marine resources. Angola has not yet developed a NPOA for addressing the bycatch or target catch of seabirds or sharks. No regulations exist at present to address seabird, shark or sea turtle bycatch. In Angola there is an additional concern regarding the directed catch of seabirds for consumption.

3. Research

There is sufficient data to assess the bycatch of seabirds in South Africa. However, data are still required to accurately estimate bycatch of the other taxonomic groups not only in South Africa but throughout the region, and this should be highlighted as a priority. The alarming capture of both demersal and pelagic sharks, the fact that longline fisheries are just one of the fisheries impacting these animals, combined with a vulnerable life history make these two groups especially important to accurately assess. This information should include data on life histories, distribution, location of nursery areas, levels of impact and possible mitigation. The International Convention for the Conservation of Atlantic Tunas (ICCAT) recently undertook an assessment of blue and shortfin mako sharks, including a review of their biology, a description of the fisheries, analyses of the state of the stocks, analyses of the effects of current regulations, and recommendations for statistics and research (Tokyo report). Due to limitations on quantity and quality of the information available, the assessment was considered very preliminary in nature. ICCAT recommends that larger monitoring and research investments directed at sharks in particular need be made. However, in short they found no evidence of stock decline.

Some research addressing the mitigation of seabird, sea turtle and shark bycatch has been conducted in the region thus far. Honig and Petersen (2005) investigated the effect of mass (4, 6 and 8kg weights) and spacing (60, 50 and 40 fathoms spacing) on line sink rates in the hake demersal longline fishery using the Spanish double line system. This study also considered the effect of these various weighting regimes on target and other non-target catch. Preliminary results reveal that by increasing the mass of the weight to 8kg the line sink rate did not sufficiently reduce the sink rate. Neither did decreasing the spacing between stones from 60 fathoms to 40 fathoms. Thus optimal sink rate and weighting regimes for this fishery remain unresolved. Investigation of tori line design, materials and efficacy has been undertaken in South Africa on both the demersal and pelagic longline fishery, although a conclusive study could still be conducted. A best-design has been included in permit conditions in South Africa. Circle hooks have been identified as a viable sea turtle bycatch mitigation measures elsewhere in the world (Watson 2003). However there is a concern that while circle hooks reduce sea turtle bycatch their effect on other non-target species is less well understood (Kerstetter and Graves 2006). A study on the use of circle is underway in South Africa. This study also considers their impact on target and other non-species. At present no studies have been conducted on reducing shark bycatch in the Benguela.

For bycatch to be reduced, we require fishers to implement mitigation measures. To achieve this we need their support and buy-in. To achieve this, mitigation measures need to be tested or demonstrated under local conditions. Since no mitigation studies have taken place in Namibia and Angola there is a need for such studies particularly in these two countries.

4. Implementation of management measures

Implementation of seabird mitigation measures has thus far not been successful. Poor compliance exists, and therefore there is a need to address enforcement and to create an environment of voluntary compliance. Low compliance is partly due to lack of enforcement which is in turn partly due to lack of awareness and understanding of permit conditions. There is, therefore a need to train compliance staff, who in many cases simply do not know of seabird mitigation measures nor do they understand why the measures are in place and how they work. Training of these officers is thus critical to the successful implementation of these measures. Another reason for low compliance is a lack of awareness amongst fishers which can similarly be addressed through training workshops and the development of awareness materials. Low compliance may also be due to a lack of participation in the process and thus there is a need to increase stakeholder involvement in developing new measures and permit conditions. This will make them feel part of the process and increase buy-in and hence lead to an improved voluntary compliance. Moreover there is a need to change the perceptions and attitudes of fishers who at present do not realise the severity of the problem nor the economic loss incurred to them from baits lost to seabirds.

Fisheries observers can also play an important role in educating fishers if appropriately trained. There may be a need to further consider the role of observers. For instance in the Patagonian toothfish fishery a five day reporting scheme has been implemented. This reporting scheme allows for vessels to be re-called to port if they are not complying to permit conditions (CCAMLR 1992). At present there is a lack of follow up when non-compliance has been reported in observer reports.

Furthermore, management systems and structures that allow for performance reporting and setting of targets are vital. These structures should include multi-stakeholder participation and allow for appraisal of performance taking all aspects of the ecosystem into consideration.

Another management tool for addressing ecosystem impacts of fisheries is the use of Marine protected areas (MPAs) (Agardy 2000). Greater use could be made of MPAs as a tool to strengthen management and to provide control sites to further scientific study and promote adaptive management (Agardy 2000). The use of spatial and temporal regulations ensures that the benefits of management are extended beyond just the target stock to the wider ecosystem, including seabirds, sea turtles and sharks. Recently, new evidence has emerged to show that MPAs do indeed improve fish yields while conserving biological diversity more generally (Jennings and Kaiser 1998). In a dynamic system such as the Benguela upwelling system it may be a challenge to attach boundaries to marine ecological processes and threats to those processes. Here living marine resources move in space and time according to processes that largely do not occur in a predictable manner. However, their application in protecting seabirds, sea turtles and sharks in pelagic waters should be considered and investigated. Areas for consideration should include shark nursery areas, seabird and sea turtle breeding sites as well as foraging areas for all three groups.

5. Conclusion

Legal and policy framework

Firstly the appropriate legislation and subsequent permit conditions need to be in place. Since this series of publications have identified substantial seabird mortality (Petersen et al. 2007) it is recommended that regulations requiring the mandatory use of seabird mitigation measures (such as bird-scaring lines, line weighting regimes and offal disposal procedures) be introduced in all three countries. Given Namibia's importance to seabird conservation they should also be encouraged to ratify ACAP and take part in their activities. None of the three countries have thus far adopted their NPOA-seabirds. South Africa and Namibia are in the process of developing a NPOA-seabirds, but Angola has not yet commenced the process.

The development of a sea turtle management policy is underway in South Africa and should be concluded and adopted as a matter of urgency. Furthermore, the implementation of mitigation measures such as circle hooks or the "move-on" rule should be considered in the pelagic longline fishery. The latter has been identified in response to high numbers of sea turtles being caught on occasion. The philosophy is that one would move to a new fishing group if large numbers of sea turtles were caught. In Angola there is a further need in the artisanal fishery to implement and enforce the ban on sea turtle and seabird capture.

Angola should be encouraged to develop an NPOA-sharks and South Africa should adopt its NPOA-sharks as a matter of urgency. The viability of the inclusion of bycatch limitations into permit conditions should be investigated.

Finally, the newly formed Interim Benguela Current Commission (IBCC) provides a platform for the harmonisation of the policy and legislative framework in the three participating nations. Given the outputs of this report we would see this as a potential 'low hanging fruit' for the Commission to tackle in its early years.

Research

Accurate assessment of seabird, sea turtle and shark catch rates should be a priority in Namibia and Angola. Special attention should be given to the sustainability of sharks' populations given the alarmingly high catch rates report in Basson *et al.* (2006). Angola is a developing country in a process of recovering from 41 years of civil warfare. As a result many communities are particularly poor and rely on marine resources such as sea turtles and seabirds to supplement their diet. Here, there is a need to conduct extensive surveys at ports, at landing beaches and within fisheries communities, including the sale of these species in their markets in order to gain insight into the dynamics of this issue under their specific conditions.

For seabirds the top priority is to identify optimal line sink rates and weighting regimes for both longline fisheries. Tori line design should further be tested and demonstrated in all three countries. For sea turtles the research priority should be investigating the effect of circle hooks on target and non-target catches. For sharks there is a need for the development of mitigation measures.

Management

South Africa should be commended for the recent introduction of seabird and turtle mitigation measures into longline fishing permit conditions. However, compliance levels to these regulations still appear to be very low. This needs to be addressed by increasing compliance efforts pertaining to ecosystem impacts. This can be facilitated through education and training of compliance officers, fisheries' observers, fishers and fisheries managers. Consultation with fishers regarding the pragmatism of mitigation measures will also facilitate implementation and compliance. In Namibia the management priority should be implementing the NPOA and thus the inclusion of mitigation measures into permit conditions. Even if this is just temporarily achieved until a thorough assessment has been carried out and made more permanent depending on assessment outcomes. In the case of commercial pelagic longliners operating in the Angolan EEZ, we recommend that these vessels carry fisheries' observers to collect bycatch data and the use of mitigation measures such as bird-scaring lines and possibly circle hooks be mandatory. All catches caught within the Angolan EEZ should be offloaded in Angolan ports to further facilitate the capture of catch information.

For fish stocks to be managed sustainably and for fishing to remain a viable source of income the integrity of the entire ecosystem needs to be considered. From a conservationists' perspective, the solution is not to shut down fisheries but rather to modify fishing operations and the type of management to reduce ecosystem impacts. The importance of stakeholder participation in management decisions, appropriate education and awareness, the correct policy and legislation coupled with the requisite political will to enter into enforceable national and international agreements to protect shared or common resources, will collectively ensure responsible fishing in the Benguela Current Large Marine Ecosystem. To further promote responsible fishing we need to enhance consumer awareness and thus create a market advantage for responsible fishers. Reducing the demand for fish unsustainably managed will reduce pressure on such marine species and allow them to recover.

All three nations, namely, South Africa, Namibia and Angola have committed to achieving the goals and targets of the World Summit from Sustainable Development (South Africa, 2002) which relate to the elimination of destructive fishing practices and application of the ecosystem approach to sustainable development of the oceans. Most importantly the newly formed Interim Benguela Current Commission can provide a platform in which the three countries can share expertise and knowledge in an effort to reduce these impacts. We would strongly encourage the Commission to develop an incidental mortality working group within its structures. This could be modelled on the very successful CCAMLR Working Group on Incidental Mortality Arising from Fishing (WG-IMAF).

Should these steps be implemented, there is reason to be optimistic about reducing the bycatch of seabirds, sharks and turtles in the Benguela current large marine ecosystem.

6. References

AGARDY, T. 2000 – Effects of fisheries on marine ecosystems: a conservationist's perspective. *ICES Journal of Marine Science.* **57**: 761–765.

BASSON, J. and S.L. PETERSEN 2006 – The impact of longline fisheries on pelagic and demersal sharks in the Benguela Current Large Marine Ecosystem. WWF South Africa report series-2007/marine001

BIRDLIFE INTERNATIONAL 2005. In: IUCN 2006. *2006 IUCN Red List of Threatened Species.* **wiucnredlist.org.**

CARRERAS, C., CARDONA, L. and A. AGUILAR 2004 – Incidental catch of the loggerhead sea turtle *Caretta caretta* off the Balearic Islands (western Mediterranean) *Biological Conservation.* **117**: 321-329

CCAMLR 1992 – CCAMLR scheme of Scientific Observation, as adopted at the eleventh meeting of the Commission (CCAMLR XI). Available at www.ccamlr.org.

CHALOUPKA, M. and C. LIMPUS 2001 – Trends in the abundance of sea sea turtles resident in southern Great Barrier Reef waters *Biological Conservation*. **102**: 235-249

COCHRANE, K.L., AUGUSTYN, C.J., COCKCROFT, A.C., DAVID, J.H.M., GRIFFITHS, M.H., GROENEVELD, J.C., LIPINSKI, M.R., SMALE, M.J., SMITH, C.D. and R.J.Q. TARR 2004 – An ecosystem approach to fisheries in the southern Benguela context. Ecosystem Approaches to Fisheries in the Southern Benguela. *African Journal of Marine Science*. **26**: 9-35.

COELHO, R., BENTES, L., GONCALVES, J.M.S., LINO, P.G., RIBEIRO, J. and K. ERZINI 2003 – Reduction of elasmobrach by-catch in the hake semipelagic near-bottom longline fishery in the Algarve (Southern Portugal). *Fisheries Science.* **69**: 293-299

COOPER, J. and P.G. RYAN 2005 – Draft South African National Plan of Action for Reducing the Incidental Catch of Seabirds in Longline Fisheries. Marine and Coastal Management, Department of Environmental Affairs and Tourism, South Africa. www.environment.gov.za**.** 98 pp.

CROXALL, J.P. and R. GALES 1998 – An assessment of the conservation albatrosses. In: Robertson G and R Gales (eds). *Albatrosses biology and conservation.* Chipping Norton: Surrey Beatty and Sons. pp 46-65

DUNDEE, B. 2003 – Draft Namibian National Plan of Action for reducing the Incidental Catch of Seabirds in Longline Fisheries. Directorate of fisheries and Marine Resources.

FAO 2004 – Code of Conduct for Responsible Fisheries. Implementation of the International Plan of Action for the Management of Fishing Capacity. Report presented at the Technical Consultation to Review Progress and Promote the Full Implementation of the IPOA to Prevent, Deter and Eliminate IUU Fishing and the IPOA for the Management of Fishing Capacity. Rome Italy, 24-29 June 2004. Available at ftp://ftp.fao.org

HONIG, M. and S.L. PETERSEN 2005 – An investigation of mitigation methods to abate bycatch of vulnerable species in the hake longine fishery. BirdLife report.

HONIG, M. and S.L. PETERSEN 2006 – The impact of longline fisheries on sea turtles in the Benguela Current Large Marine Ecosystem. WWF South Africa report series-2007/marine001

ICCAT 2003 – Report of the Sub-Committee on Bycatch. Appendix 9 in Report from the meeting of the Standing Committee on Research and Statistics. Madrid, Spain, 6-10 October 2003. Available at www.iccat.es

ICCAT 2004a – Report from the meeting of the Standing Committee on Research and Statistics. Madrid, Spain, 2004. Available at www.iccat.es.

ICCAT 2004b – Report of the meeting of the Sub-Committee on Bycatch. Appendix 9 in the Report of the Standing Committee on Research and Statistics, Madrid 4-8 October 2004. Available at www.iccat.es

ICCAT 2004c – Tokyo Report: Report of the 2004 inter-sessional meeting of the ICCAT sub-committee on bycatches: shark stock assessment. Tokyo, Japan, 14-18 June 2004. www.iccat.es

JENNINGS, S. and M. KAISER 1998 – The effects of fishing on marine ecosystems. *Advances in Marine Biology*. **34**: 201–352.

KERSTETTER, D.W. and J.E. GRAVES 2006 – Effects of circle versus J-style hooks on target and non-target species in a pelagic longline fishery. *Fisheries Research.* **80**(2-3): 239-250

LEWISON RL, FREEMAN SL and L.B. CROWDER 2004 – Quantifying the effects of fisheries on threatened species: the impacts of pelagic longlines on loggerhead and leatherback sea sea turtles. *Ecology letters.* **7**: 221-231

MEGALOFONOU, P., DAMALAS, D. and C. YANNAPOULOS 2005 – Composition and abundance of pelagic shark by-catch in the eastern Mediterranean Sea. *Cybium*. **29**(2): 1350-140

NEL, D.C., RYAN, P.G. and B.P. WATKINS 2002 – Seabird mortality in the Patagonian toothfish longline fishery around the Prince Edward Islands, 1996-2000. *Antarctic Science*. 14: 151-161

PETERSEN, S.L., HONIG, M. and NEL, D.C. 2006 – The impact of longline fisheries on seabirds in the Benguela Current Large Marine Ecosystem. WWF South Africa report series-2007/marine001

RYAN, P.G. and C. BOIX-HINZEN 1998 – Tuna longline fisheries off southern African: the need to limit seabird bycatch. *South African Journal of Science.* **94**: 179-182

SEAFO. 2001 – Convention on the Conservation and Management of Fishery Resources in the South East Atlantic Ocean. Adopted in Windhoek, Namibia, 20 April 2001. Available at www.oceanlaw.net/texts/seafo.htm

SHANNON, L.J., COCHRANE, K.L., MOLONEY, C.L. and P. FREON 2004 – Ecosystem approach to fisheries management in the Southern Benguela: A workshop review. Ecosystem Approaches to Fisheries in the Southern Benguela. *African Journal of Marine Science.* **26**: 1-8

SPOTILA, J.R., REINA, R.R., STEYERMARK, A.C., PLOTKIN, P.T. and F.V. PALADINO 2000 – Pacific leatherback sea turtles face extinction. *Nature.* **405**: 529–530.

WATSON, J.W., FOSTER, D.G., EPPERLY, S. and A. SHAH 2003 – Experiments in the Western Atlantic Northeast distant waters to evaluate sea sea turtle mitigation measures in the pelagic longline fishery. U.S. Department of Commerce National Oceanic and Atmospheric Administration NOAA Fisheries http://www.mslabs.noaa.gov/mslabs/docs/pubs.html

UNITED NATIONS 2002 – Report on the World Summit on Sustainable Development, Johannesburg, South Africa, 26 August – 4 September 2002. www.un.org

Legal Sources and Agreements

1969 International Commission for the Conservation of Atlantic Tuna (ICCAT)

1979 Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention or CMS)

1982 Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR)

1982 United Nations Convention on the Law of the Sea, U.N. Doc. A/CONF. 62/122; 21 *ILM* (1982) 1261

1993 FAO Agreement to Promote Compliance with Conservation Measures on the High Seas, 33, *ILM* (1994), 969, *B&B Docs*, 645

1995 FAO International Code of Conduct for Responsible Fisheries

1995 UN Agreement Relating to the Conservation and Management of Straddling Fish Stocks and Migratory Fish Stocks, 34 *ILM* 1542; (1995) 6 *RECIEL* 841

1999 MOU concerning Conservation Measures for Marine Sea turtles of the Atlantic Coast of Africa

2001 Convention on the Conservation and Management of Fishery Resources in the South East Atlantic Ocean (‘SEAFO’)

2001 SADC Protocol on Fisheries

2002 Agreement for the conservation of Albatrosses and Petrels (ACAP)

National Legislation

Angola:	Aquatic Biological Resources Act, 2005
Namibia:	Marine Resources Act, 2000
South Africa:	Marine Living Resources Act, 1998

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