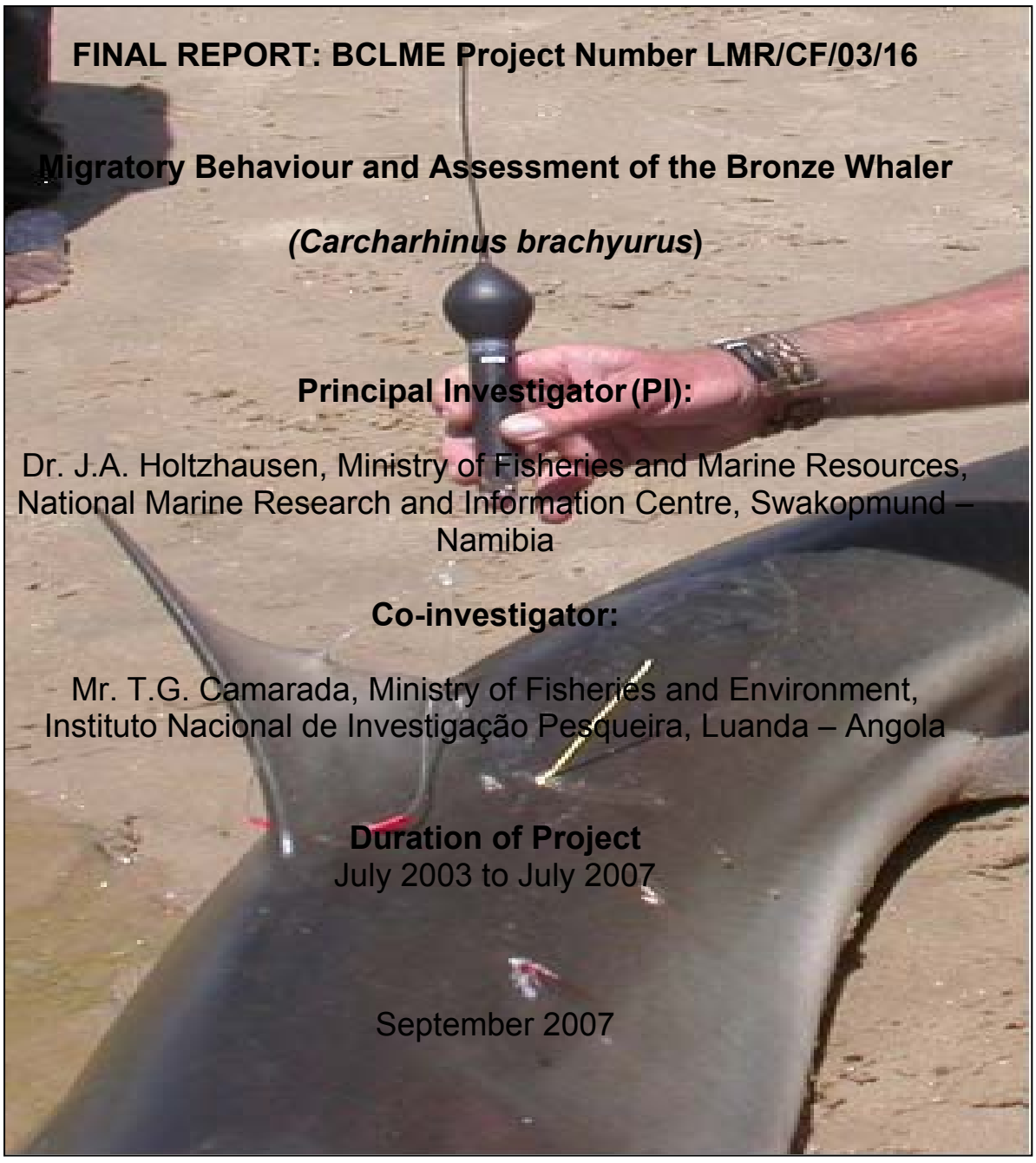
BENEFIT

BCLME
Benguela Current Large Marine Ecosystem Programme



FINAL REPORT: BCLME Project Number LMR/CF/03/16

Migratory Behaviour and Assessment of the Bronze Whaler

(*Carcharhinus brachyurus*)

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Duration of Project
July 2003 to July 2007

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List of acronyms

BCC	Benguela Current Commission
BCLME	Benguela Current Large Marine Ecosystem
BENEFIT	Benguela Environment Fisheries Interaction and Training Programme
CBD	Convention on Biological Diversity
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
EEZ	Exclusive Economic Zone
GPS	Global Positioning System
ICCAT	International Commission for the Conservation of Atlantic Tunas
IPOA	International Plan of Action
K	Growth
KZN	Kwazulu Natal
$L\infty$	L infinity, asymptotic length (mean length of very old fish)
MFMR	Ministry of Fisheries and Marine Resources
MPA	Marine Protected Area
NACOMA	Namibian Coast Conservation and Management Project
NAFTAP	Namibian Angling Fish Tagging Project
NERC	Natural Environment Research Council
NL	Notch Length
NM	Nautical miles
NOCS	National Oceanography Centre, Southampton
NPOA	National Plan of Action
NTB	Namibia Tourism Board
ORI	Oceanographic Research Institute
PSAT	Pop-up Satellite Archival Tags
SADC	Southern African Development Programme
SIDA	Swedish International Development Agency
t0	t-zero, initial condition parameter (in years)
TL	Total Length
UK	United Kingdom
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Programme
USA	United States of America

Acknowledgements

We thank the BCLME and BENEFIT for making this project possible and the respective Ministry's of Fisheries of Angola and Namibia for allowing us official time to complete this project. We are very grateful to all the Namibian shark anglers for instigating the project and their tagging effort and personal inputs specifically with regard to the socio-economic survey. We are grateful for the initial corporate sponsorship to start the project.

Abstract

The bronze whaler is Red Listed as Near Threatened globally (NT), Vulnerable (V) in East Asia, Data Deficient (DD) in the East Pacific but of Least Concern (LC) in New Zealand, Australia and South Africa simplified by having most, if not all of the population resident within each nation's EEZ.

Carcharhinus brachyurus is a large coastal shark with low productivity and although circumglobal, regional populations appear to be discrete, and it does not appear to be naturally abundant anywhere.

Results from conventional tag-recapture since 1984 show that in southern Africa these trans-boundary sharks occur in two discrete populations, one from the West Coast to the East Coast of South Africa, and the other ranging between central Namibia and southern to central Angola. 5043 Bronze whalers were tagged in Namibia and 281 in southern Angola between December 1984 and June 2007. Recapture rate was 2.91% with the longest distance moved 1781 km southwards and the highest number of days at liberty was 3713. Of 4666 bronze whalers tagged in South Africa only one individual tagged in False Bay near Cape Town was recaptured in Namibia near Swakopmund and similarly only on individual tagged in Namibia near Swakopmund was recaptured also at False Bay, Cape Town.

Twelve individual recaptures showed conclusively that adult bronze whalers ranged between central Namibia and southern Angola. Two large males and two large females were fitted with Archival Pop-up Satellite tags in Namibia. Of these one female released in February in northern Namibia moved 707 km northwards into central Angola and then returned to the same place where it was released the following January. The other female moved 200 km southwards from central Namibia where she unfortunately died after 66 days. The other three satellite tags failed. A distinct seasonal movement of adult sharks could be detected between Namibia and Angola.

Baia dos Tigres in southern Angola was identified as a breeding and nursery area through examining sex ratios and noting the presence or absence of juveniles. Pregnant females occur in central Namibia in summer and it is hypothesised that the

pupping area is close offshore. For the first time ever in 2006 and 2007 bronze whalers were found at Meob Bay, 160 km south of Walvis Bay although no anomalies in SST occurred in these two years.

The Namibia/Angolan stock could not be assessed due to the paucity of catch and effort data of bronze whalers harvested in Angola. The economic survey showed that currently 10 Namibian angling guides take out 3600 clients (average 3 clients/day on a 6-day week for 200 days per year) specifically for bronze whaler angling, annually generating at least U$1 million to the economy of the country (excluding travelling costs). This figure could be as high as U$4 million if the guides could expand their operations to take out 6 clients on a 6-day week for 300 days per year. It is proposed that the Namibian guides should form an association to regulate this sport fishery. Only three fishing camps in Angola currently offer guided angling tours but not specifically for bronze whaler sharks. No socio-economic data is available for Angola.

Namibia implemented a National Plan of Action for the management of its sharks in 2003 while Angola is in the process of doing so. It is proposed that no commercial harvesting of bronze whalers should be allowed in Namibia or Angola and that Baia dos Tigres in southern Angola should be declared or re-zoned as a Marine Protected Area. Through the Namibian Coast Conservation and Management Project (NACOMA), some MPA's are in the process of being declared in southern Namibia which should include the bronze whaler pupping areas.

1. Baseline Information

1.1 FishBase Description (1984)

Scientific name: *Carcharhinus brachyurus*

Family: Carcharhinidae (Requiem sharks)

Order: Carcharhiniformes

Class: Elasmobranchii (sharks and rays)

FishBase name: Copper shark

Distribution:

Gazetteer Western Atlantic: Mexico, Gulf of Mexico, Brazil to Argentina. Eastern Atlantic: off France southward and around the coast of southern Africa to central Natal, South Africa (Ref . 5578), including the Mediterranean. Possibly two separate populations in southern Africa (Ref. 3209). Western Pacific: Japan to New Zealand. Eastern Pacific: southern California, USA to the Gulf of California in Mexico and Peru.

Diagnosis: Dorsal spines (total): 0-0; Anal spines: 0-0. A large shark to with a bluntly pointed, broad snout, narrow, bent cusps on the upper teeth, and with no interdorsal ridge (Ref. 5578). Grey to bronzy in color, white below (Ref. 5578); fins mostly plain except for dusky tips on pelvics, as well as dusky to black tips and rear edges on pectoral fins (Ref. 9997).

Biology: A coastal and offshore shark (Ref. 9997) found along continental margins in most tropical and temperate seas. Occasionally enters large coastal bays and inshore areas (Ref. 6390). Occasionally found near the bottom (Ref. 6808). Migratory in the northern part of its range, moving northward in spring and summer and southward in autumn and winter (Ref. 244). Feeds on pelagic and bottom bony fishes, cephalopods, and small sharks and rays (Ref. 5578). Undoubtedly utilized for human consumption where it occurs (Ref. 244). Implicated in shark attacks on people (Ref. 9997).

Max. size: 325.0 cm TL (male/unsexed); max. weight: 227 kg

Environment: pelagic; brackish; marine ; depth range 0 - 100 m

Climate: subtropical; 45°N - 52°S
Importance: gamefish: yes
Threatened: Near Threatened globally (NT)
Dangerous: traumatogenic
Coordinator: *Compagno, Leonard J.V.*
Main Ref: Compagno, L.J.V.. 1984. (Ref. 244)

1.2 Introduction

This common inshore shark species (also known as copper shark) with a circumglobal distribution is also the only member of the genus *Carcharhinus* that occurs in temperate waters. Not only is the bronze whaler the slowest growing member recorded from this genus but also one of the slowest growing of all shark species (Walter & Ebert 1991). This, together with a late age at sexual maturity, low fecundity and its inshore habits make it extremely vulnerable to over-exploitation. Indications were that two separate populations occur in southern Africa: one distributed from the Western Cape eastwards and the other from just south of Walvis Bay northwards into southern Angolan waters. Preliminary tag-recapture results indicated that Namibia and Angola share the same bronze whaler population.

In Namibian waters bronze whalers are primarily targeted during fishing competitions and these sharks also support lucrative angling-tour operations around the central coastal towns. Sport anglers, mostly from overseas, pay large amounts of money to catch-and-release a bronze whaler in Namibian waters and with an aggressive marketing campaign in Europe, this type of fishing holiday is becoming increasingly popular. The contribution of this sport fishery to the Namibian economy was unknown. As these sharks are only caught for recreational purposes from the shore in Namibian waters, all are returned alive to sea.

In contrast, Angola suffered from the ravages of a 27-year civil war that only ended in February 2002. As a consequence, the once thriving southern coastal ports of Tombwa and Namibe, which historically supported a healthy fishing industry harvesting the abundance of diverse fish species, fell into disrepair, the infrastructure crumbled and the economy faltered. Thus, harvesting of fish along this stretch of coast during the war was minimal resulting in current healthy populations.

One pelagic longliner started to harvest bronze whalers in the second quarter of 2001 in Baia dos Tigres in the south of Angola (northern Benguela), and landed about 80 tons of bronze whaler per month. Ilha dos Tigres is the largest island off Angola with a surface area of 98 km^2 while the bay (Baia) supports a rich diversity of marine fauna, notably sharks. The meat and fins were off-loaded in Walvis Bay harbour (Namibia) but could not be traced. Subsequently, in August two more longliners started harvesting this species there and by the end of September two Spanish freezer boats also started harvesting there. In October rumour had it that two more Walvis Bay registered boats were also preparing to catch bronze whalers there. This could have resulted in the seven boats harvesting over 200 tons/month or 4 000 sharks per month. No shark fishery concentrating their efforts on one species and at one place can sustain this type of harvest. However, it was learned in January 2002, that these boats have moved away from Baia dos Tigres and were fishing for sharks north of Namibe.

At the time only one angling tour operator offered angling tours from the shore or skiboat in southern Angola with its base camp, Flamingo Lodge, near Namibe and a semi-permanent camp, Foz do Cunene, near the Kunene River mouth. His clients were mostly from overseas or South Africa and they mostly targeted the abundant, larger sub-tropical fish species from the shore or from a skiboat. Sharks were not the preferred species.

As indications were that Namibia and Angola share one bronze whaler stock, Namibian anglers were therefore most concerned that uncontrolled harvesting of the species in Angolan waters will have a negative effect on the recreational bronze whaler fishery in Namibia. By late September 2001, they therefore requested the Namibian Ministry of Fisheries & Marine Resources, through the press, to take action to safeguard the bronze whalers. For this reason this project was launched with the aim of it becoming a joint project between NatMIRC and INIP under the BENEFIT programme or the BCLME programme. Eventually, after many negotiations and private corporate sponsorship to start the project in January 2002, the project was registered as a BCLME project in June 2003 and from then on was financially administered by BENEFIT.

This project was then formulated with the objective being to conduct a study of bronze whaler resources to determine its distribution, abundance and population structure in order to ensure sustainable management of the resources in the region

(Angola and Namibia). The most important questions were to investigate if Namibia and Angola share one bronze whaler resource and to determine if this species can be sustainably harvested in Angola without having a negative influence on the Namibian bronze whaler sport fishery. From the results, a joint management plan would then be formulated to the benefit of both countries. (See Project TOR in Appendix 1)

1.3 Key Questions

a) Through tag-and-release, determine to what extend bronze whalers migrate (seasonally) between Namibia and Angola.
b) Through tag-and-release combined with a genetic study, delimit populations and their boundaries, if any, between South Africa, Namibia and Angola.
c) Determine the breeding/nursery area(s) of this species in the region.
d) Could bronze whalers be sustainably harvested in southern Angola and what would the effect be on the recreational tourism-based industry targeting this species in Namibia?

2. Setting and regional context

2.1 Study Area & Environment

The BCLME region is defined as the area from Port Elizabeth (34ºS, 25.6ºE) on the East Coast of South Africa to the Congo River mouth (6ºS, 12.6ºE) in the Cabinda province of northern Angola. Of interest to this project was the area from about Cape Point (34.3ºS, 18.4ºE) to south-central Angola in the vicinity of Namibe (15ºS, 12ºE) as recapture data indicated that two bronze whaler populations might exist in this region, one occurring from south of Walvis Bay along the West Coast of South Africa and the other from Walvis Bay northwards to Angola (Figure 1).

2.2 The Benguela Upwelling System

Namibia's marine environment falls within the Benguela upwelling system, one of the four major eastern boundary current systems of the world (Sakko, 1998). The Benguela system encompasses the entire region that can be affected by the upwelling phenomenon, from Cape Agulhas (35°S), the southern tip of the African continent, along the eastern edge of the southern Atlantic Ocean to the Angolan port of Namibe. Upwelling systems are characterised by the presence of cool surface waters and high biological productivity. The Benguela Current is furthermore unique in that it is bounded at both ends by warm water currents, poleward by the Agulhas Current and equatorward by the Angolan Current (Shannon, 1985). It flows equatorwards along the Namibian coast and is deflected away from the coast by the Coriolis force due to the earth's eastward rotation and the prevailing southerly winds which consequently leads to upwelling (Lalli and Parsons, 1993).

The Angola-Benguela Front, situated roughly opposite the mouth of the Kunene River, is where the north-flowing Benguela Current meets the south-flowing Angola Current. This front is a permanent feature of the sea surface and is maintained throughout the year in a narrow band of latitude, between 14 and 16°S (Shannon, 1985). It migrates southwards annually and introduces warm, saline and nutrient-poor Angolan water into Namibian coastal waters to a depth of about 100 m, and is associated with a relaxation of the equatorward, upwelling-favourable wind-stress (Boyd, Salat and Maso, 1987).

This phenomenon sometimes leads to mass mortalities of marine organisms including linefish.

In the Benguela system the prevailing south to south-westerly winds move nearshore surface water northwards and offshore, which is then displaced by cool, central water welling up from a depth of about 300 m (Shannon, 1989). These southerly winds are caused by the high pressure over the south Atlantic in combination with the pressure field over the southern sub-continent (Shannon, 1985). Upwelling off Namibia is in phase with the seasonal insolation1998). Consequently, food availability varies in such systems, which is normally exceptionally abundant but unpredictable, variable and unevenly distributed. Characteristically, these systems support a low species diversity but at the same time being among the most productive habitats in the world.

The unusually intense perennial upwelling cell off Lüderitz effectively divides the Benguela upwelling system into a southern part and a northern part (Shannon, 1989). The northern Benguela upwelling system extends from Lüderitz as far north as the Kunene River mouth where it is deflected westward and off shore by the Angola Front. Off Lüderitz and Cape Frio, the 200 m contour lies particularly close to the coast, and a steep bottom slope occurs. The narrowing of the shelf at these localities coincides with areas of enhanced upwelling activity. Although upwelling in the Benguela system occurs throughout the year, the main upwelling period is between March and November with a peak in August (Shannon, 1985).

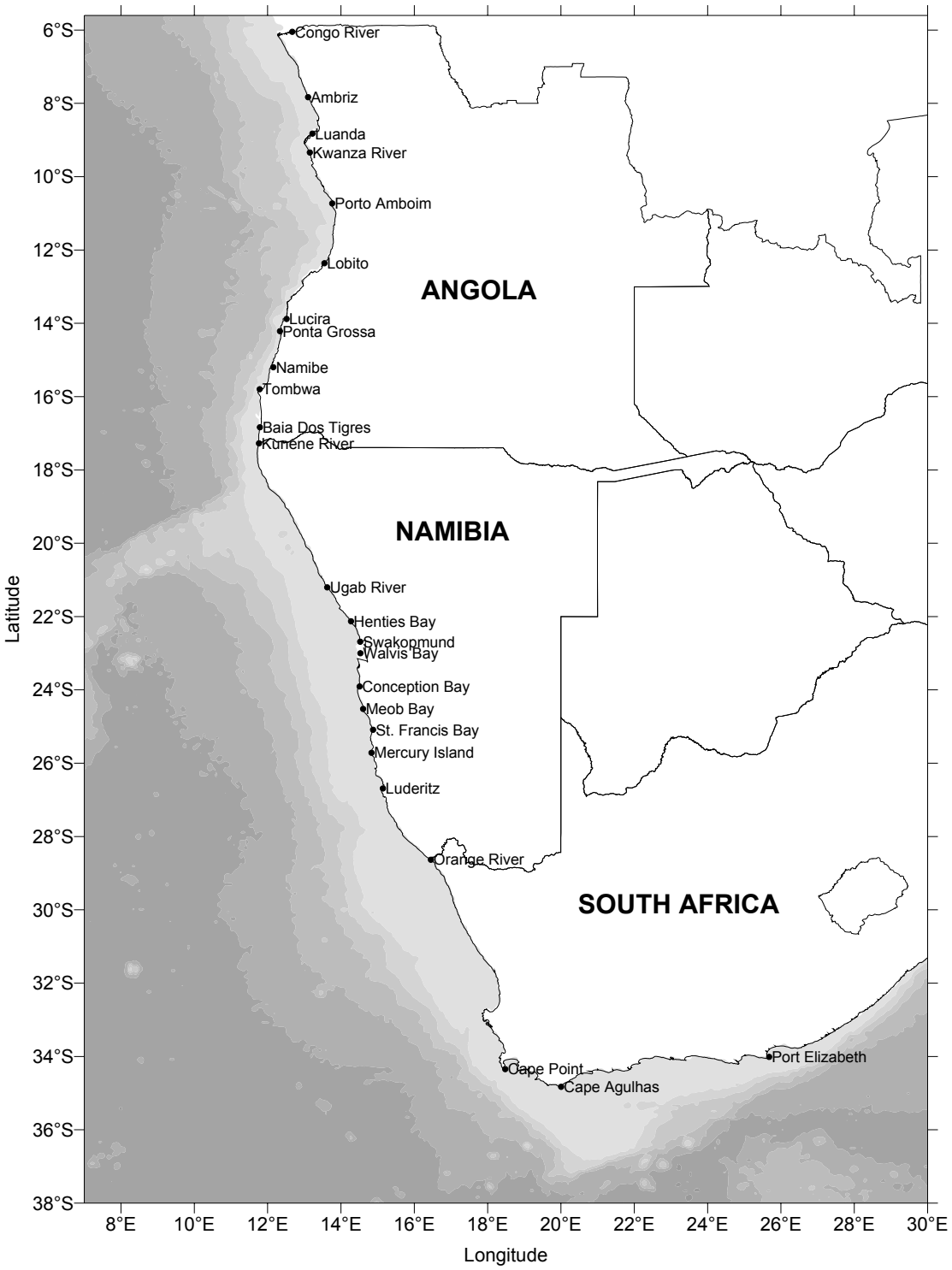

Fig. 1. Map of the BCLME coastline from Port Elizabeth to the Congo River also indicating depth contours. Sandwich Harbour could not be included as it overlaps on the map with Walvis Bay.

2.3 Biological Boundary

A natural biological boundary exists in the vicinity of Meob Bay and Sylvia Hill which somehow prevents fish species crossing this imaginary line. Agenbag and Shannon (1988) suggested that the cold core of the Benguela in the vicinity of Lüderitz provide

a barrier to the interchange of biota between the northern and southern parts of the Benguela system. Although surface distributions of temperature, salinity and chlorophyll-a revealed no significant longshore gradients to explain this boundary, the distribution of shoals, commercial catches and larvae of pelagic fish species in the Benguela ecosystem pointed to a well-defined biological boundary near 24º30´S in the vicinity of Meob Bay. Upwelling in the Lüderitz cell produces one or more cold water filaments, of which the larger appears to be semi-permanently positioned with its northern edge approximately off Meob Bay. This could be the combined effect of changes of circulation and turbulence/stratification that causes the biological discontinuity.

This biological boundary is of importance for this study as tag-recapture results showed that except for two bronze whalers that have crossed this imaginary line, no other of the ±10 000 tagged have done so.

2.4 Anomalies in the Benguela System

The unstable and unpredictable marine environment of the Benguela system leads to irregular anomalies, especially a rise in water temperature. These temperature anomalies raise primary production, lower dissolved oxygen concentrations, and cause algal blooms which are harmful to some forms of marine life such as fish. High water temperature stimulates the bacteria that produce hydrogen sulphide. Each of these factors may have significant effects on the marine biota and ultimately on different fish species.

Although Namibia is known for its shore-angling opportunities, environmental conditions play a vital role in the availability of fish to the angler. The strong south-westerly winds that generate upwelling, have a negative impact on angling success. They cause large swells and turbulent water which hampers casting distance, causes the bait to drift and thereby reduces soak time of the bait that should attract the fish. When warm water events occur, angling fish species, including bronze whalers do not take bait and are therefore not available to the angler. Similarly, when sulphur is present in the water, experienced anglers know that they will not catch any fish from the shore and they will therefore not go fishing. In the region of Sandwich and Walvis Bay in particular, sulphur eruptions are common their effects may last for several days during which time no fish will be landed from the shore (J.A.H., pers obs.). In the northern Benguela system, sulphur outbreaks occur in the inshore coastal waters

as a result of the decay of the benthos. Occasionally the hydrogen sulphide bubbles rise to the surface, resulting in a sulphur eruption.

2.5 Shore Topography and Surf-zone Dynamics

Namibia and Angola each has a coastline of approximately 1 500 km long, of which the entire Namibian coast and about 300 km of southern Angola fringe the Namib desert, the oldest desert in the world. This coastline follows a regular north-south direction and has many shallow embayments and only two natural harbours at Lüderitz and Walvis Bay (Namibia) and two in southern Angola namely Tombwa and Namibe. In Namibia rocky shores are common south of Meob Bay, whereas sandy shores dominate the central region. Mixed sand and rocky shores characterise the northern region. Lagoon shores occur at the Orange River mouth, Lüderitz, Sandwich, Walvis Bay and at the Kunene River mouth.

The southern Angolan coastline from the Kunene River mouth to Tombwa consists entirely of sandy shores and with about a 50% mixture of sandy shores and rocky shores up to Namibe. A lagoon shore occurs only at Baia dos Tigres. From Namibe northwards the coastline changes to almost entirely steep rocky shores.

For this project a total of 48 shallow bays were identified between the Orange River and Namibe in southern Angola. Fifteen occur between Chameis Bay and Lüderitz. Another 11 occur between Lüderitz and Walvis Bay. However, no bronze whalers were found in any of these bays except at Meob Bay and Sandwich Harbour.

In Lűderitz two sightings of juvenile bronze whalers where reported during this project. From Meob Bay to the Kunene River mouth another 22 bays occur and in most of these bays bronze whalers can be found if environmental conditions are right. The significance of this is that from Meob Bay northwards up to Flamingo Lodge in southern Angola bronze whalers are found in most bays. In contrast no bronze whalers are found south of Lűderitz which is a further indication that two separate populations of bronze whalers occur in the BCLME region.

During this project it was found that bronze whalers normally are found in bays and shallow areas where shoals of mullet (*Liza richardsonii, L. dumerili*) occur which are an important food source for them. No mullet shoals were observed south of Lűderitz and no bronze whalers were found in that area. However, from Meob Bay northwards

mullets shoals are common specifically at Sandwich Harbour, Bosluisbaai and Baia dos Tigres where bronze whalers occur in abundance.

2.6 Description of Geographical Regions

2.6.1 Southern region

The area from the Orange River mouth northwards up to the southern boundary of the Namib Naukluft Park at Gibraltar (26.0°S, 14.934°E) is a closed, diamond-mining area, known as the Sperrgebiet, and controlled by NAMDEB (NamibiaDeBeers). Between the Orange River mouth and Lüderitz the fauna of the rocky intertidal zone is typical of the cool-temperate southwest (Namaqua) province and conforms closely to that of the west coast south of the Orange River (Penrith and Kensley, 1971).

The area between Gibraltar and the southern boundary of Sandwich falls within the Namib Naukluft Park and is a closed area under the jurisdiction of the Ministry of Environment and Tourism (MET) of Namibia. The shoreline consists entirely of sandy beaches with dunes up to the high-water mark.

The Meob Bay area is also situated within this area and is the most southerly place on the Namibian coast where large concentrations of West Coast steenbras (*Lithognathus aureti*) and silver kob *(Argyrosomus inodorus*) occur. Surf-zone sharks are bronze whaler (*Carcharhinus brachyurus*) and broadnose sevengill cow shark (*Notorynchus cepedianus*). The effect of the biological boundary is clear between Sylvia Hill and Gibraltar where Hottentot (*Pachymetopon blochii*) replaces galjoen and geelbek (*Atractoscion aequidens*) and white stumpnose (*Rhabdosargus globiceps*) replace silver kob and West Coast steenbras respectively. During this project no bronze whalers were found south of Meob Bay although local fishermen from Lűderitz have reported two sightings of juvenile bronze whalers in the Lűderitz lagoon.

2.6.2 Central region

From Sandwich Harbour (40 km south of Walvis Bay) northwards to the Ugab River mouth lies the open angling area of approximately 325 km of shoreline accessible to anglers, except for a stretch of 25 km which is closed to angling. This closed area, bordering Mile 72, is the Cape Cross Seal Reserve (21.750°S, 13.967°E). Lineboats

may operate anywhere in the central area, while anglers may fish in this area throughout the year.

The towns of Walvis Bay, Swakopmund and Henties Bay, and the village Wlotzkas Baken, are located within the WCRA. The shoreline of the WCRA consists of a mixture of sandy and rocky shores.

2.6.3 Northern region

The area north of the Ugab River mouth to the Kunene River mouth is called the Skeleton Coast Park and is managed as a wilderness area by MET, that is, an area of minimum development and limited public access. The Skeleton Coast Park has a coastline of approximately 515 km which consists of a mixture of sandy and rocky shores.

Situated eighty km north of Terrace Bay is an embayment called Möwe Bay (19.367°S, 12.700°E) where a small settlement, serving as the headquarters of MET personnel patrolling the Skeleton Coast Park, is situated. This is the last human settlement to be found along the northern Namibian coastline and from there northwards to the Kunene River mouth, a distance of approximately 285 km, no further infrastructure exists.

Near the Kunene River mouth another shallow embayment, Bosluis Bay (17.367°S, 11.750°E), occurs and, together with the 14 km stretch of coast from there to the Kunene River mouth, constitutes the most northerly portion of the southern African marine region on the west coast (Penrith, 1982). It is also situated close to the southern boundary of the subtropical West African faunal province. From south to north along the west coast there is a regular decrease in numbers of southern African fish species, whereas at the boundary of the west African province there is a dramatic and sudden increase in the number of west African fish species (Penrith 1982).

2.6.4 Far-northern region

The southern Angolan coastline from the Kunene River mouth to Tombwa consists entirely of sandy shores and with about a 50% mixture of sandy shores and rocky shores up to Namibe. A lagoon shore occurs only at Baia dos Tigres. From Namibe northwards the coastline changes to almost entirely steep rocky shores.

In summary, it can be said that the Namibian coastline and southern Angola up to Namibe falls entirely within a dynamic and unpredictable upwelling system, while a biological boundary in the Lüderitz-Meob Bay region divides the greater Benguela system in two, a northern and southern system. The waters of the northern region are generally oxygen-poor. The fauna within the Benguela Current system represents both the cool-temperate southwest (Namaqua) province and the warm-temperate northwest (Namibe) province with an intermediate zone near Rocky Point. Fish species diversity declines from north to south while endemic species of the intertidal invertebrate fauna of the southern African region declines from south to north (Penrith and Kensley, 1971).

3. Tag-and-release Programme

3.1 Introduction

The distinct movement patterns of a fish species throughout its range and in the various stages of its life may have implications for the management of the population or stock. The dispersal of eggs and larvae by currents, settlement into estuaries or intertidal pools in the post-larval stage, movement of juveniles into juvenile areas (shallow sandy shores) and thereafter into adult feeding areas are important life history phases to understand a species' population dynamics. Migratory patterns of adult fish, especially of the spawner stock, and the dispersal of individuals into areas adjacent to where they have spent their early life, must be known if a stock is to be assessed or to be managed as a unit stock. The identification of discrete stocks is also basic to the conservation and rational exploitation of fisheries resources (Lenfant and Planes, 1996).

Throughout the world the method of marking and recapturing fish is used to study fish movements. Although it is time consuming, labour intensive and usually involves long-term studies, results from this methodology can be most informative. The tag-and-release of fish species involves catching fish individually, usually with hook and line, marking them and releasing them at the same site (Holtzhausen, 1996; Holtzhausen and Kirchner, 1998; Van der Bank and Holtzhausen, 1998/1999, Holtzhausen, Kirchner & Voges 2001, Holtzhausen 2003).

The main thrust of a tagging programme would be to aid management of the species firstly by providing hard data on the shark's occurrence, when and where, and to gather data on their biology such as the size frequencies, morphology, sex ratio and breeding state. The hope of any tagging programme is to yield movement data through recaptures. Secondly by engendering a higher regard for the species to the public.

Some historical tag data indicated that there could be a seasonal movement of bronze whalers between Namibia and Angola. At the onset of winter in April/May in Namibia the water temperature in the Benguela Current drops below 16°C at which time the bronze whalers move northwards into southern Angola regulated by the warm waters of the Angolan Current. Here they would spend the winter months

probably for breeding and possibly also for pupping in sheltered bays such as Baia Dos Tigres. At the onset of the austral summer at about October/November the water temperature in Namibia rises again to above 16°C and the bronze whalers would start moving southwards and inshore into central Namibia. Nine bronze whalers that were tagged in central Namibia before this project started in 2002 were recaptured in southern Angola between Baia Dos Tigres and Flamingo camp. However, since no bronze whalers were tagged in Angola prior to the inception of this project, none could be expected to be recaptured in Namibia.

Angola has been devastated by civil war for 27 years since 1975 until a ceasefire was reached on 11 April 2002. The first exploratory trip to southern Angola for this project occurred in the beginning of February of the same year but ended in failure as the team was denied entrance at the Oshikango border on 5 February. However, it would take another 10 months of careful planning to reach the Flamingo Lodge near Namibe to investigate shark angling and tagging opportunities in Angola.

3.2 Method (conventional tags)

Bronze whalers were caught with rod-and-reel from the shore – this is a very specialised field and only expert shark anglers are used. Depending on the size of the shark and the skill of the angler, it can take between 15 minutes and two hours to land a bronze whaler. Because of their immense power, the shark needs to be hooked in the dorsal fin with a gaff when it is near the beach and then pulled manually out of the water.

Conventional dart anchor tags (Hallprint, Australia) were used to tag bronze whalers using standard procedures. The alpha numerically numbered tags are inserted with an applicator just posterior of the dorsal fin. Biological data such as notch length (NL) were taken by measuring the shark from the tip of the snout to the caudal pit anterior to the tailfin. The shark was also visually classified as male or female by observing the external sex organs. The date was noted and also the GPS readings.

For this project, 1805 bronze whalers were tagged between January 2002 and July 2007. This exercise included;

- three overland tagging surveys conducted into southern Angola (260 tagged),
- seven surveys to the Skeleton Coast Park (280 tagged),

- two surveys to the most southern parts of Namibia (11 tagged), and
- also six one-day tag surveys to Sandwich Harbour (172 tagged).

Angling guides tagged a further 1082 bronze whalers in central Namibia for the project.

Since 11 November 1984 up to 8 April 2001, anglers participating in the South African-based Sedgwick's/ORIWWF Tagging Program have tagged a total of 2395 bronze whalers in Namibia of which 64 were recaptured again (Bullen & Mann, 2002). To date, 4660 bronze whalers were tagged through the ORI Programme in South Africa of which only one was recaptured in central Namibia.

Since October 1991 to end December 2001 a further 1124 bronze whalers were tagged in Namibia under the NAFTAP programme (Namibian Angling Fish Tagging Project).

3.3 Results (conventional tags)

3.3.1 Distances moved

Conventional tag-and-recapture results from this project showed that the southern limit of the distributional range of bronze whalers is at Meob Bay with the northern limit being in the vicinity of Namibe. Therefore the coastline was divided into three areas,

1) the central area between Meob Bay up to the Ugab River (390km),
2) from the Ugab River to the Kunene River (500km) and
3) from the Kunene River to Namibe (260km).

For the ORI programme in Namibia a total of 18 bronze whalers were recaptured at the same locality as their point of release, 28 moved northwards (9 were recaptured in Angola, 7 at Baia dos Tigres ± 75km north of the Kunene River mouth and 2 at Flamingo Lodge 200km north of the Kunene River mouth) and 18 moved southwards. Of these 18 none were recaptured further south than Paaltjies near Walvis Bay. However, since no bronze whalers were tagged in Angola before this project none could be expected to be recaptured in Namibia. It was only during this project that bronze whalers were tagged for the first time in Angola.

For the NAFTAP programme and this project combined 90 recaptures were recorded of which the tagging data of 72 were usable. Ten were recaptured at the same

locality as their point of release, 29 moved northwards (3 were recaptured in Angola, 2 at Baia dos Tigres and 1 at Flamingo Lodge) and 33 moved southwards of which only one moved all the way down to False Bay, Cape Town (in 2006) and 4 moved from Angola into Namibia (this project) which are the important ones. Of the 4660 bronze whalers tagged so far in South Africa alone, only one individual that was tagged in False Bay, Cape Town were recaptured at Mile 6 near Swakopmund.

Figure 2 shows the results of all 136 recaptures combined. Two bronze whalers were recaptured the same day they were tagged with the maximum days at liberty were 3713 with an average of 554 days. Twenty eight bronze whalers were recaptured at the same locality as their point of release with the maximum distance moved was 1781 km south with the average distance moved in a southerly direction being 155 km. Fifty eight bronze whalers moved north with the furthest distance being 890 km and the average northerly movement being 191 km. From the figure it is clear that most bronze whalers moved in a radius of 250 km. Overall indications are that bronze whalers generally move in a northerly direction with the current.

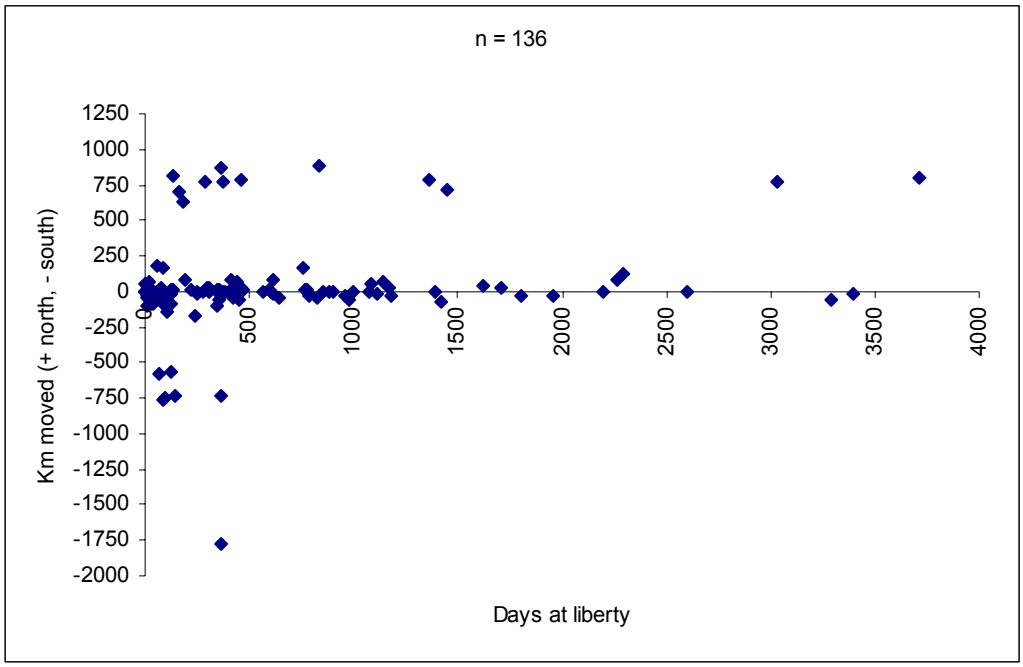

Figure 2. Distance moved in kilometres and days at liberty for bronze whalers tagged and recaptured in Angola, Namibia and one recaptured in South Africa.

The mean distance travelled by tagged *C. brachyurus* in South Africa is 163 km during 162 days at liberty, the maximum distance travelled was 1,320 km (Cliff and Dudley 1992). In South Australia tagged adults have been re-sighted at their tagging

location after a year at liberty suggesting this species, like other carcharhinids, is philopatric (I. Gordon, pers. obs.). Movement between New Zealand and Australia, or other regional populations has not been documented. *Carcharhinus brachyurus* occur singly and in loose schools sometimes numbering hundreds of individuals (Smale 1991; Cappo 1992; Cliff and Dudley 1992; C. Duffy unpublished data).

One of the aims of this project was to prove that Namibia and Angola share the same population of bronze whalers. A total of 12 bronze whalers tagged in Namibia were recaptured in southern Angola with 4 tagged in southern Angola during this project being recaptured again near Swakopmund. One tagged bronze whaler was also recaptured at Baia Dos Tigres from the ORI project and although the tagging details were not in ORI's databank, it was established that this shark was tagged near Swakopmund in approximately March 1996. It was thus re-caught after about 6.5 years and 770 km to the north (not included in graph). Also, four bronze whalers tagged at Baia Dos Tigres during this project were subsequently recaptured near Swakopmund, 751 km to the south; all on average after three months. This effectively confirms the hypothesis of one population shared between Namibia and southern Angola.

3.3.2 Seasonal movements

One of the hypotheses was that at the onset of summer in September/October, adult bronze whalers start moving southwards from southern Angola into Namibian waters where they would then spend the summer in central Namibia. At the onset of winter in May/June they would start moving back into the warmer Angolan (warm Angolan Current) waters. Tables 1 and 2 confirm this hypothesis and clearly show such a seasonal movement.

Table 1. Table indicating seasonal southward movement of bronze whalers from north to south at the onset of the austral summer in Namibia.

Tag station	Tag date	NL cm	Recap place	Recap date	Days free	Distance km
Bosluisbaai	Aug-03	149	Ugab	Oct-03	66	-582
Bosluisbaai	Aug-03	151	Swakopmund	Nov-03	98	-746
Baia Dos Tigres	Aug-03	168	Swakopmund	Nov-03	84	-762
Bosluisbaai	Aug-02	171	Langstrand	Dec-02	142	-728
Bosluisbaai	Aug-02	159	Swakopmund	Dec-02	123	-565
Baia dos Tigres	Nov-02	151	Swakopmund	Dec-03	368	-738

All these female bronze whalers started to move southwards from the extreme north to central Namibia as summer approaches and the water temperature increases. Note that only one of these has been free for a whole year and that the others completed these large distances between 2 – 4 months.

Table 2. Table indicating seasonal northward movement of bronze whalers at the onset of the austral winter in Namibia.

Tag station	Tag date	NL cm	Recap place	Recap date	Days free	Distance km
Swakopmund	Oct-97	172	Baia dos Tigres	Jul-01	1365	780
Langstrand	Mar-01	150	Baia dos Tigres	Jul-01	130	807
Dolfynstrand	May-91	170	Baia dos Tigres	Jul-01	3713	801
Mile 8	Apr-93	163	Baia dos Tigres	Jul-01	3035	766
Mile 8	May-96	167	Baia dos Tigres	Nov-96	165	766
Mile 8	March-97	172	Flamingo Camp	Jun-99	836	890
Horingbaai	Jan-01	161	Baia dos Tigres	Jul-01	180	634

Unfortunately the gender of these bronze whalers is not known. The table illustrates that bronze whalers start moving to the warmer waters of southern Angola at the onset of the Namibian winter. Note that some of these were free for some years and could thus have completed the annual movement pattern a few times.

However, this type of tag-recapture results only shows the point of recapture relative to the point of release. It does not show the “path” the shark followed as it moved. Thus many of the 28 recapture results that showed no movement could have been the result of the shark having moved far but have returned to the point of release. An individual could even have done so year after year. Therefore, to investigate seasonal movement patterns four Pop-up Satellite Archival Tags (PSAT’s) were used in this project.

3.4 Using Satellite Technology

Argos PTT-100 Archival Pop-up Tags from Microsoft Telemetry, Inc. Columbia Maryland, USA.

This short communication was posted in July 2003 by Mike Musyl to describe the use of satellite tags. “Integrating the latest technology into their research strategy, scientists from the National Marine Fishery Service's Honolulu Lab and the University

of Hawaii Joint Institute for Marine and Atmospheric Research are tackling many questions about the ecology and management of pelagic (open ocean) fishes and sea turtles in the Pacific Ocean.

Using archival and pop-up satellite archival tags, the scientists are generating a "treasure trove" of immediately useful data. These data are key in addressing a number of critical management questions, including investigating post-hooking survivability, identifying possible spawning areas and delimiting stock boundaries. Field studies are being led by NOAA Fisheries' scientist Richard Brill and Michael Musyl and Yonat Swimmer of University of Hawaii's Pelagic Fisheries Research Program".

3.5 Tag description

The concept of Argos Pop-up tags has been proven over the last few years by the many successful deployments of first generation Archival Pop-up tags. The second generation Archival Pop-up tag presented here is a logical progression in the development of Pop-up tags. Based on the same proven pressure housing and release mechanism as the original single point Pop-up tag, this tag incorporates a totally new sensor interface and "Fuzzy Logic" based data processor, connected to the well-proven Pico PTT. The tag is highly adaptable via software changes.

The time of sunrise and sunset, for use in geo-locating the tag each day, together with hourly temperature and pressure readings can be recorded for over a year within the tag and then transmitted to Argos (France), via the PTT, after pop up. Incorporated into the data stream along with the archival data are real time temperature and battery voltage together with real time clock calibration checks and a CRC16 checksum.

The tag can be programmed to release either on a specific date or after a preset time on the fish (e.g., three months) — this mode is best for studies with an indefinite start date. Should the tag go below a preset depth, or remain at a "constant depth" (e.g., on the bottom or at the surface indicating the animal has died) it will release from its tether, surface and initiate data transmissions to Argos. This device can be deactivated as was the case for this project.

Given good sea state conditions the tag can transmit a year's worth of data through the present Argos system (seven satellites) in about ten days at mid latitudes, after

pop up. The SiV™ (Satellite in View) duty cycle timer extends the transmission time out to about one month so allowing adequate time for data retrieval through the system.

The initial costs for these tags are high (± U$2 500 each in 2003), but can be rebooted at U$820 each.

3.6 Method (satellite tags)

Bronze whalers are very active sharks frequenting very shallow waters when hunting. A characteristic of these sharks is that they frequently jump right out of the water falling back onto the surface on their sides creating a big splash. The reason for this is unknown but it might be a way of dislodging ecto-parasites although no such parasites were ever observed on any individual caught during this project.

Therefore, attaching the tag to the shark had to be done in such a way that it would not fall off during the shark's activities. After much correspondence and trail and error, a round hole (± 5mm diameter) was punched through the thick fleshy part of the dorsal fin. A round plastic sleeve was then passed through the hole. A long-enough leaderline was then passed through the sleeve and passed through the 'eye' of the tag and securely knotted so that the tag did not snag on the posterior side of the dorsal fin as the shark steered with its dorsal fin. (See picture 2 in Annex)

3.7 Results (satellite tags)

On the 3rd of December 2003, the four Argos pop-up tags arrived from Microwave Telemetry, USA. These sophisticated tags are custom built for each client and these specific ones were set to release on December 6th 2004. The reason for this date is that it coincides with the height of the holiday season in Namibia and therefore a released tag washed up on the beach could easily be picked up by anglers.

On 7 December 2003, a female bronze whaler was caught at Mile 17 (near Swakopmund) and fitted with the first ever satellite pop-up tag in Namibia. Three days later one large male and one large female were fitted with satellite tags at Bosluis Bay near the Kunene River.

Unfortunately, all three satellite tags started to transmit after four days which meant that they have prematurely released from the sharks. They have a built-in device which assumes that the fish/shark have died when it stays at a constant depth for 4 days and then automatically releases the tag which then start transmitting to Argos. These devices were not de-activated by the manufacturers as requested. This was a national disaster for the project. Unfortunately, when this device is de-activated the tag will not start transmitting if it deploys prematurely but will only do so on at the pre-set release date.

Using the internet medium the tag released at Mile 17 was found 8 days later in a tent of a camper at Jakkalsputz, 20km to the north from where it was released. The other two tags could also be tracked through the Internet medium. Both drifted northwards and one came ashore at Baia dos Tigres while the last signal received from the second one was near Namibe about 200km further north.

Microwave Telemetry subsequently donated 3 new tags and the remaining one was sent back for alterations and rebooting. Having suffered a 2-month setback, all five tags were subsequently deployed. One released after 6 months (shark died) and it was sent back for rebuilding and then deployed again. Of the other 3, one recorded for the full 9 months (tag 44774) and valuable data was recorded. The other two never surfaced on the release date and are presumed lost. The last tag deployed in March 2005 did not surface on its release date of 15 October and is presumed lost too.

Both these data sets were sent to Dr. Tony Booth of Rhodes University for re-calculating and improving the movement data of these two sharks using the Kalman Filter technique, which is a computational (recursive) means to estimate the state of a process, in a way that minimizes the mean of the squared error (Sibert, Musyl, & Brill, 2003). The filter is very powerful in several aspects: it supports estimations of past, present, and even future states, and it can do so even when the precise nature of the modelled system is unknown. This will eliminate error data and smooth out the movement patterns of these sharks. This analysis worked well for the dataset provided by tag 44774 but failed on the dataset of tag 44771. The results for the latter tag just show that the shark swam in a straight line to the area where she died. Dr. Booth double-checked these results against other software but the results were identical. Therefore, the most southerly point recorded by the PSAT is taken as the point where she died.

3.7.1 Tag 44771

This female bronze whaler was caught at Langstrand at 17H30 on 7 February 2004. She weighed ± 140kg and measured 221cm NL. She did not seem pregnant and was fitted with a satellite tag (ID 44771, serial 6729) and a conventional dart tag (L0605). From the unfiltered data it seems that this female bronze whaler has travelled past Saddle Hill to 4 km past Gibraltar (26.018°S) a distance of 390 km (Fig. 3).

Here she unfortunately died after 122 days and sank to a depth of 123m (Fig. 4) on the ocean floor. After 132 days the tag detached from the body, floated to the surface and then the current transported it in 17 days to Henties Bay 475 km to the north. The tag was found on the beach by an angler who notified Fisheries. This tag was refurbished and rebooted by Microwave and was attached to another bronze whaler in mid-March 2005 but failed to report at the pop-off date.

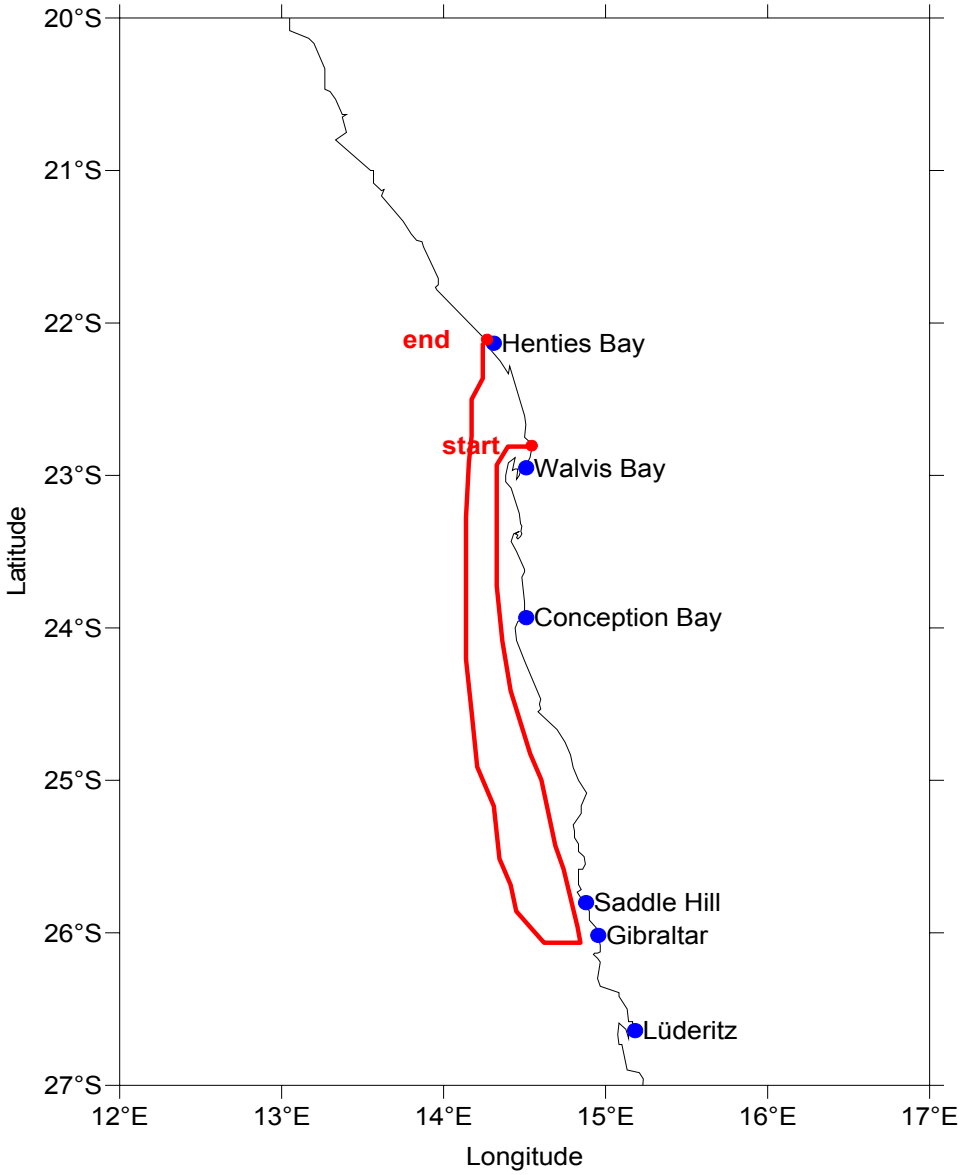

Figure 3. Movement of female bronze whaler from where she was released (start) to Gibraltar where she died and path of the tag carried by the current to where it came ashore at Henties Bay.

She frequently dived to depths of ± 25m (Fig. 4) and the surface temperature ranged between ± 16-23°C. Water temperature fluctuated between 18-22°C with depth as she dived (Fig. 5).

In the literature maximum reported depth is 100m but it is likely to range deeper (Compagno 1984; Smale 1991; Last and Stevens 1994).

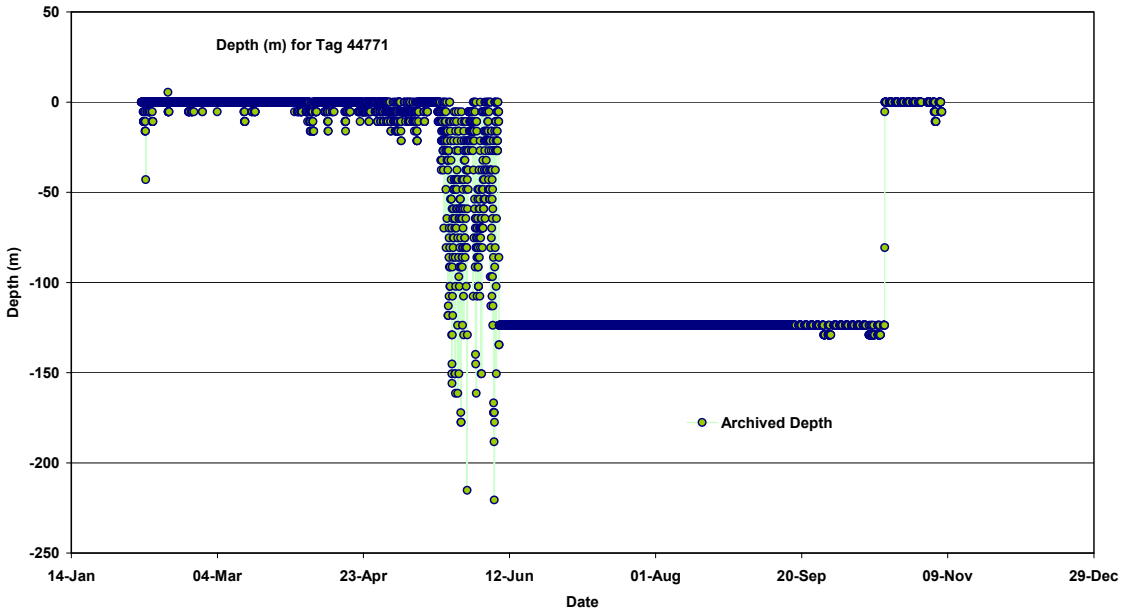

Figure 4. Dive profile for tag 44771.

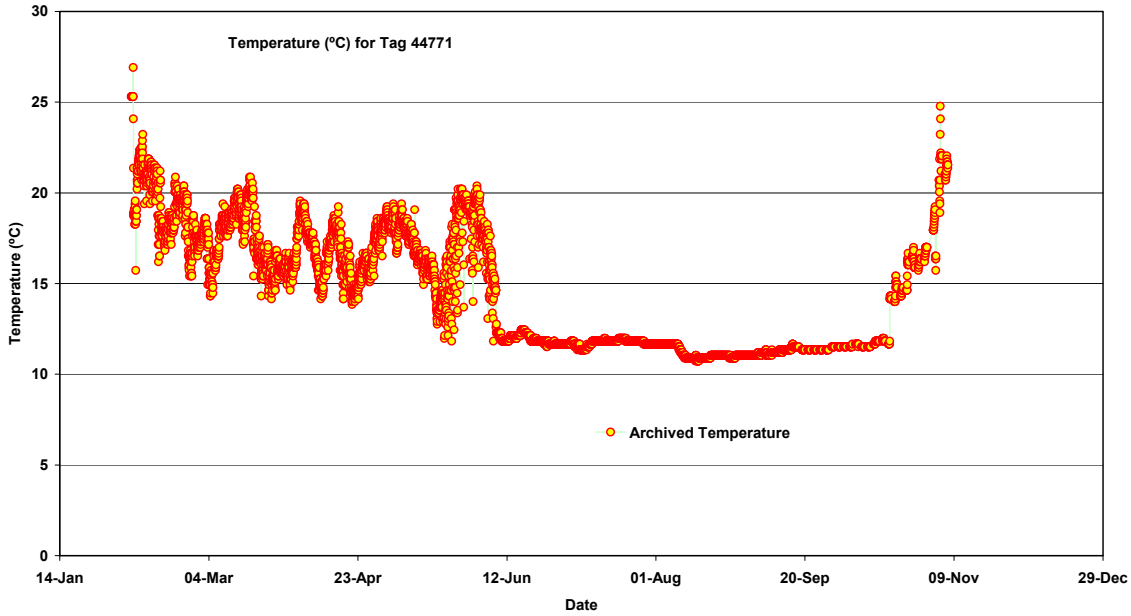

Figure 5. Temperature profile for tag 44771.

3.7.2 Tag 44774

This female bronze whaler was caught at Bosluisbaai on 7 April 2004 at 16H00. She weighed ± 95kg and measured 195cm NL. She was in good physical condition. The filtered results (Kalman filter see Sibert, Musyl & Brill, 2003) show that she swam

northwards for 707 km to an area 40km north of Lobito where she turned around (date unfortunately unknown). She then swam southwards for 568 km and the tag ended up on the beach 139 km north of her point of release (Figure 6).

However, if one takes into account that it could be that the tag detached from her earlier than the release date, it is possible that she had moved into Namibian waters and that the tag had released at 18.016°S as indicated by the average Argos latitude data. This means that the tag could have detached on 24 November 2004 as indicated by the pressure data and then drifted 226km in 69 days to near Tombwa where it started transmitting on 31 January 2005 for 5 weeks until 2 March 2005. Unfortunately this tag could not be retrieved in time and it is presumed that a local might have picked it up or that it got buried under the shifting beach sand.

The sunrise and sunset time for each day are used to calculate the latitude and longitude points. This calculation is inaccurate around the equinox because at this time of year the day length differs little from latitude to latitude. Since tag 44774 was active around the fall equinox, all the estimated latitude points from September 4 to October 15 were removed from the Microwave Telemetry report.

The implication of these results is that they strengthen the hypothesis that adult bronze whalers undertake seasonal dispersion between Namibia and Angola as was also indicated by the 4 bronze whalers tagged at Baia Dos Tigres in southern Angola.

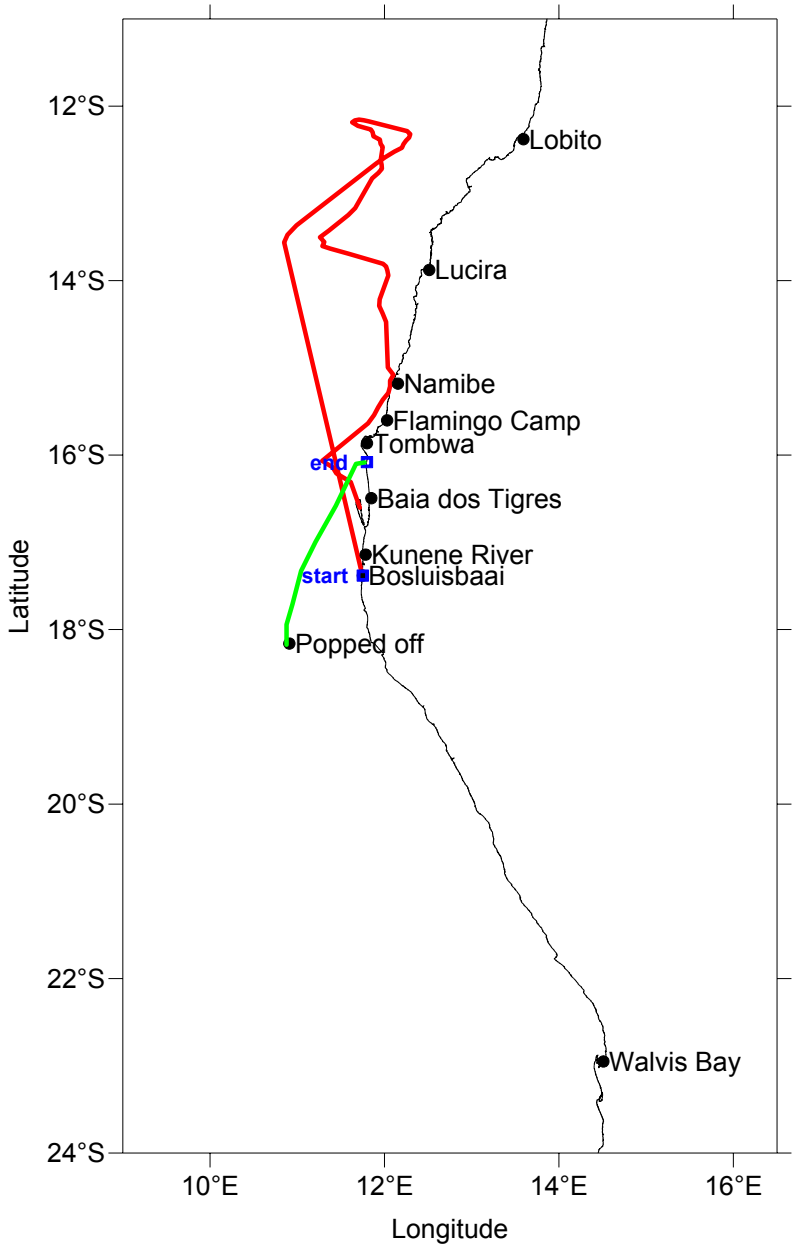

Figure 6. Movement of female bronze whaler from where she was released at Bosluisbaai to Lobito where she turned around to approximately where the tag released and path of the tag carried by the current to where it came ashore south of Tombwa.

She also frequently dived to depths of ± 25m (Fig. 7) and preferred a surface temperature of between ± 17-24°C (Fig. 8). The green points on this graph show real temperature measurements of up to 40°C which is indicative of sand surface temperatures on the beach near Tombwa for mid-summer. This indicates that the tag has washed ashore and was lying buried or on top of the sandy beach. Of interest was that during the daytime the shark preferred shallow water depths but during the night she would do shallow dives to 22m deep. She possibly hunted for bottom living

species during the night and in shallow waters during the day for inshore fish or small shark species.

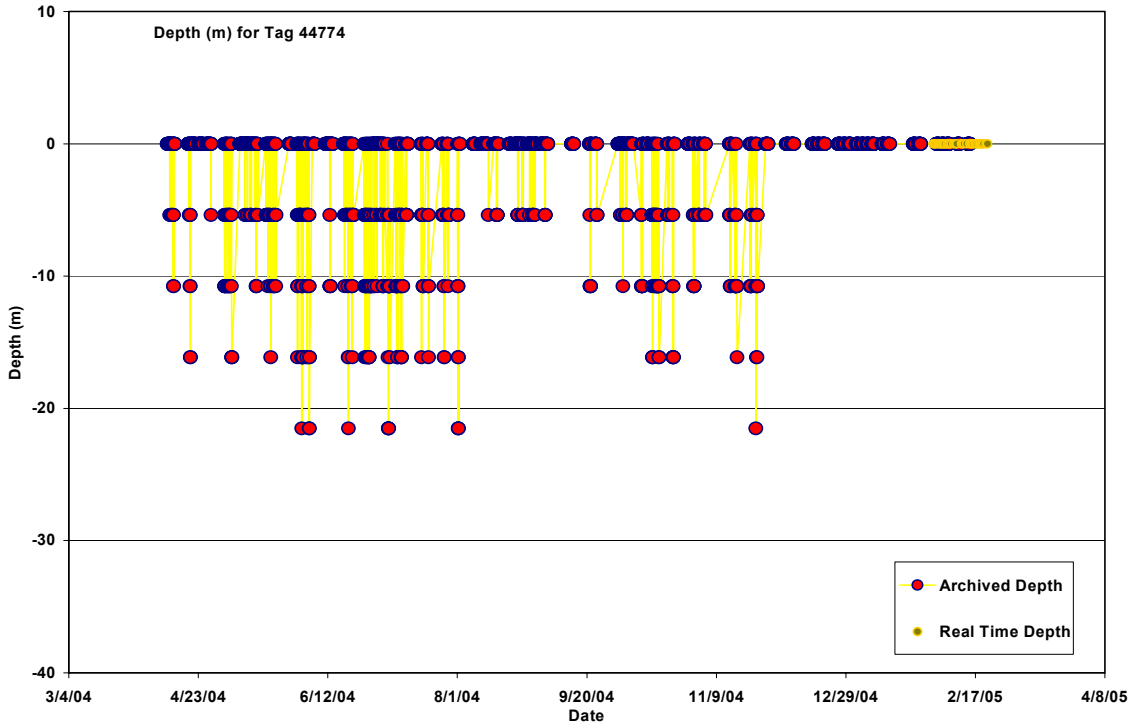

Figure 7. Dive profile for tag 44774.

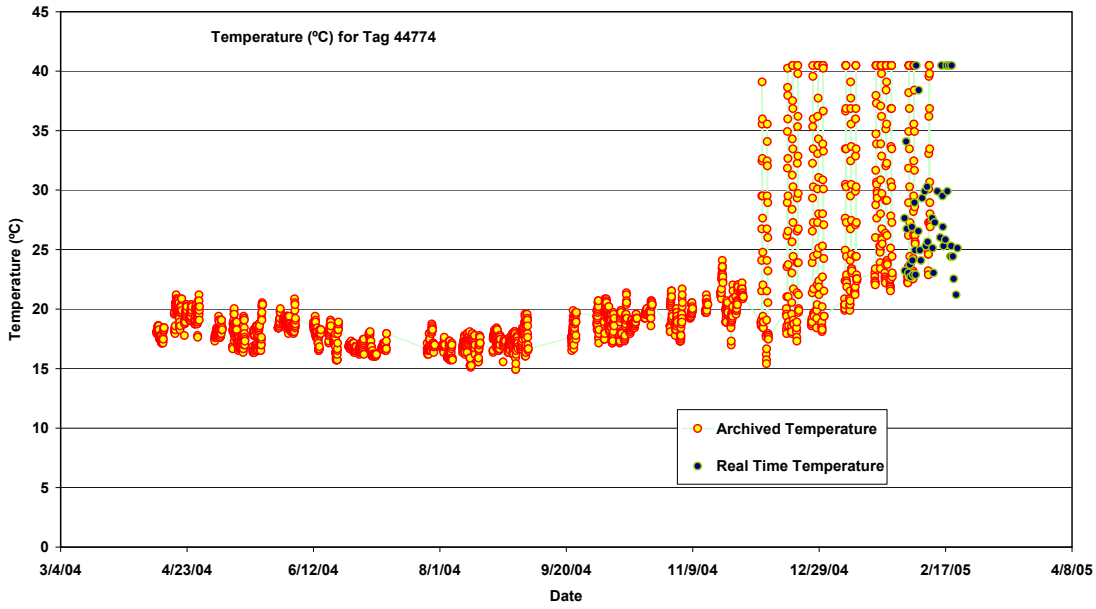

Figure 8. Temperature profile for tag 44774.

Brill and Musyl (2003) reported on 57 sharks (bigeye thresher (*Alopias superciliosus*), blue (*Prionace glauca*), oceanic white-tip (*Carcharhinus longimanus*) and shortfin mako (*Isurus oxyrinchus*)) fitted with PSAT's in the central north Pacific Ocean. Of interest was that off 22 male sharks tagged, only 23% of PSAT's have reported. In contrast, of the 22 PSAT's deployed on female sharks, 73% reported. This difference occurred irrespective of shark species. This could indicate that male sharks are much more active than females and therefore their rate of tag loss is much greater.

The same results were achieved during this project in that only the female shark's PSAT's have reported and none from the male sharks.

3.8 Conclusions

- Conventional and satellite tag-recapture results confirm that Namibia and Angola share one bronze whaler population.

- Conventional tag-recapture results further indicate that a separate population occurs from the West Coast of South Africa to the East Coast. Of more than 10 000 bronze whalers tagged in South Africa, Namibia and Angola only two have crossed the South Africa/Namibian international border.

- There is a definite seasonal movement of adult bronze whalers between southern Angola and central Namibia. At the onset of summer, adults move from southern Angola to central Namibia where they will stay until the onset of winter and then move back into southern Angolan waters.

4. Reproductive Biology & Breeding areas

4.1 Introduction

Information about the life history and biology of this apex feeder is limited. Except for a few studies on bronze whalers from southern Africa (Bass *et al.* 1973; Walter & Ebert 1991; Compagno 1984 (citations); Van der Elst 1981 (citations)) and other areas (Garrick 1982; Hildebrand 1946), no research has been done on any shark species occurring in Namibian or Angolan waters prior to this project.

Of importance to managing shark stocks are studies on age, growth and reproduction, because such data can give information on stock composition, age at maturity, lifespan, mortality, growth, production and yield (Tesch, 1968). Walter and Ebert (1991) derived length-at-age data, size at birth, size and age at maturity, growth (K), $L\infty$ (asymptotic length) and t_0 (initial condition parameter) from 61 bronze whaler from South Africa. These parameters could be used in an appropriate fishery model to assess the bronze whaler stock if a time series of catch data is available.

4.2 General biology

The bronze whaler is essentially a temperate and sub-tropical species (Garrick 1982; Compagno 1984b; Muñoz-Chápuli 1984; Smale 1991; Cappo 1992; Cliff and Dudley 1992; Chiaramonte 1998). According to Walter and Ebert (1991) it is the only carcharhinid occurring in temperate waters which might explain why it has the slowest growth rate of all the carcharhinids. It is a widespread but patchily distributed coastal and shelf species, occasionally reported from oceanic areas close to the continental shelf (Amorim *et al*. 1998; Marín *et al.* 1998; Bagley *et al*. 2000). It enters shallow water (Ayling and Cox 1982; Cappo 1992; Last and Stevens 1994) and also occurs in brackish or freshwater in the lower reaches of large rivers and estuarine bays (Last 2002).

Maximum size attained is at least 295cm TL for South Africa, and it is reported to reach 350cm TL in Australian waters (Ayling and Cox 1982; Compagno 1984; Last and Stevens 1994). Size at maturity is between 206–235cm TL (males), and 227–244cm TL (females). Length at 50% maturity for KZN (South Africa) is 175cm NL for males and 190cm NL for females (Cliff and Dudley 1992). This is the length where 50% of the females in the population have reproduced once.

Age at 50% maturity for South Africa is 20 years for males and 26 years for females, re-estimated by Smale (2000) from Walter and Ebert (1991) while the latter authors estimated the maximum age to be 30 years in South Africa.

The male:female sex ratio for KZN is 1.2:1 with considerable monthly variation according to Cliff and Dudley (1992) while Smale (1991) found this to be 1:1 for sharks of 1-2m TL and 1:1.3 for sharks smaller than 1m TL in the south eastern Cape, South Africa.

From a National Sharks Board publication (Cliff and Dudley, 1992) the length/weight relationship for bronze whalers are;

males: mass(kg) = 7.49×10^{-6} NL(cm)$^{3.11}$,

females: mass(kg) = 6.71×10^{-6} NL(cm)$^{3.14}$ while

total length/notch length relationship is: TL(cm) = 1.251 x NL(cm) + 15.68.

4.3 Reproductive biology

While Bass *et al.* (1973) found no breeding seasonality in the bronze whaler, Hildebrand (1946) and Garrick (1982) both found embryos slightly smaller than size at birth in mature females caught during winter. Castro *et al.* (1999) postulated that reproductive periodicity is probably biennial like most other large carcharhinids. However, Cliff and Dudley (1992) estimated gestation lasts ~12 months, but could be 15–21 months. Walter and Ebert (1991) estimated the gestation period as between 1-2 years which compares favourably with that of a few other carcharhinid species of similar size.

Mating probably occur from May to August in South Africa with parturation occuring between September to January (Smale 1991; Cliff and Dudley 1992). Walter and Ebert (1991) provided evidence that parturation in Namibia occur between December and March. Heavily pregnant females were caught at Sandwich Harbour during this project (Holtzhausen pers. obs). Reproduction is viviparous, with a yolksac placenta (Bass *et al*. 1973, Smale 1991).

Litters range from 7–24 pups (average 15 reported from South Africa) (Garrick 1982; Smale 1991; Cliff and Dudley 1992; Chiaramonte 1998). Size at birth is ~60cm TL (range 55–67cm TL) (Garrick 1982; Smale 1991; Cliff and Dudley 1992). Productivity is estimated to be low to very low, with a minimum population doubling time of more than 14yrs (K=0.04) (Froese and Pauly 2002).

4.4 Breeding, Pupping & Nursery areas

Despite the importance of sharks to marine ecosystems as top predators and growing concern over the conservation status of many shark species, surprisingly little is known about many aspects of their reproduction patterns and life history. Better knowledge of breeding biology and reproductive parameters will be important for designing appropriate management plans to protect dwindling populations of sharks.

As an example, in 2001, Feldheim, Gruber and Ashley reported new information regarding the mating system and reproductive cycle of a large coastal shark, the lemon shark *Negaprion brevirostris,* revealed through field observations and genetic analyses of an adult female and her offspring. Their findings demonstrate that this female exhibited philopatry to a nursery ground in Bimini, Bahamas, where she returned to give birth in both 1996 and 1998. Genetic analyses using DNA microsatellite loci developed for lemon sharks provided the first demonstration of polygamous mating and multiple paternities in a carcharhinid shark; at least three males had sired the litter she delivered in 1998. This has behaviour has never been noted in sharks before and could possibly imply that bronze whalers too breed and pup at the same sites each year or each second year.

4.4.1 Breeding area

A breeding area is defined here as an area where adult bronze whalers converge to breed. Breeding scars (bites) are sometimes fresh on females. Adults are defined as males larger than 175 NL (size at 50% maturity) and females larger than 190 cm NL (size at 50% maturity) after Cliff and Dudley (1992)

4.4.2 Pupping area

Smale (1991) found that in the Eastern Cape, South Africa bronze whalers pupped offshore as heavily pregnant females were found in water depths of 40-50m. Given the concept that nurseries are supposed to be refuges from cannibalism, this deep-water preference of pregnant females would be to prevent cannibalism. Walter and Ebert (1991) reported near-term pregnant females between December and March in central Namibia and this was confirmed during this project. It is suspected that pupping occurs off-shore in Namibia as in the Eastern Cape.

Neonates are defined as recently-born with the open umbilical scars to umbilical scars that are closed.

4.4.3 Nursery area

Nursery areas are normally shallow bays or estuaries into which the neonates would later move as there is normally an abundance of food and for safety from larger predatory fish.

As one of the project investigators for another BENEFIT estuaries project, the PI visited the Rio Longa (central Angola) estuary in December 2004 and the Kwanza River mouth with the co-investigator in September 2005. Anecdotal evidence suggested that these might be a nursery area for bronze whalers (presence of neonates) but during on-site examinations of the catches of subsistence fishermen in both areas, no neonate, juvenile or adult bronze whaler was found. It might be that the locals confuse juvenile dusky shark *Carcharhinus obscurus* or juvenile milkshark *Rhizoprionodon acutus* occurring in these warmer waters with bronze whalers.

In March 2005, the area between Namibe and Lucira was surveyed overland to fish for bronze whalers and to search for breeding/pupping/nursery areas. However, not a single bronze whaler could be found. However, three dusky sharks (*Carcharhinus obscurus*) were caught during this survey. This species normally replaces the bronze whaler in sub-tropical habitats. Naturally no breeding areas could be defined (presence of neonates) as not a single bronze whaler was caught despite our best efforts.

4.4.4 Juvenile area

This area is defined here as the inshore area into which juveniles from a certain length (± 70cm NL) move from the nursery area. They would stay in this area for feeding until the reach sexual maturity when they will move to the breeding area for the fist time.

For this part of the project the study area was at first divided into four areas, 1) the southern area between Orange River mouth to Sylvia Hill, (500km), 2) the central area between Meob Bay up to the Ugab River (500km), 3) the northern area from the Ugab River to the Kunene River (500km) and 4) the far-northern area from the

Kunene River mouth to Namibe (250km). However, as no bronze whalers were found in area 1 (Orange River to Sylvia Hill) the study area was divided in the same three areas as described in the previous chapter as areas 1-3.

4.5 Length frequency distribution

Springer *op cit.* (1967) in Smale (1991) described the commonly observed patterns of segregation by size and sex in sharks whereby adults and juveniles also segregate, possibly to avoid the threat of cannibalism. Bronze whalers are usually segregated by sex throughout their range in Namibia during this project. It was found that when fishing for bronze whalers at a suitable location it might happen that for the first hour, only females will be caught after which they would disappear and then only males will be caught for the next hour.

As the presence of neonates and juveniles will be indicative of pupping, nursery or juvenile areas, the length frequency distributions for these three geographical areas were calculated and are presented in figures 9-11. At birth bronze whalers are between ~60cm TL (range 55–67cm TL) (Smale 1991; Cliff and Dudley 1992) which relates to between 43-55cm NL. Even though Walter and Ebert (1991) suggest that the recruitment of neonates into the fishery is knife-edged (will take bait immediately) they probably are most likely not able to the large baits shark anglers use and therefore they might be present in the area but not available. One of these authors (JPW) has seen several females with near-term embryos in summer (December-March) along the Namibian coast

4.6 Sex ratio

As sex ratios might also indicate breeding areas with the presence of many more females than males, the sex ratios are also included in these graphs.

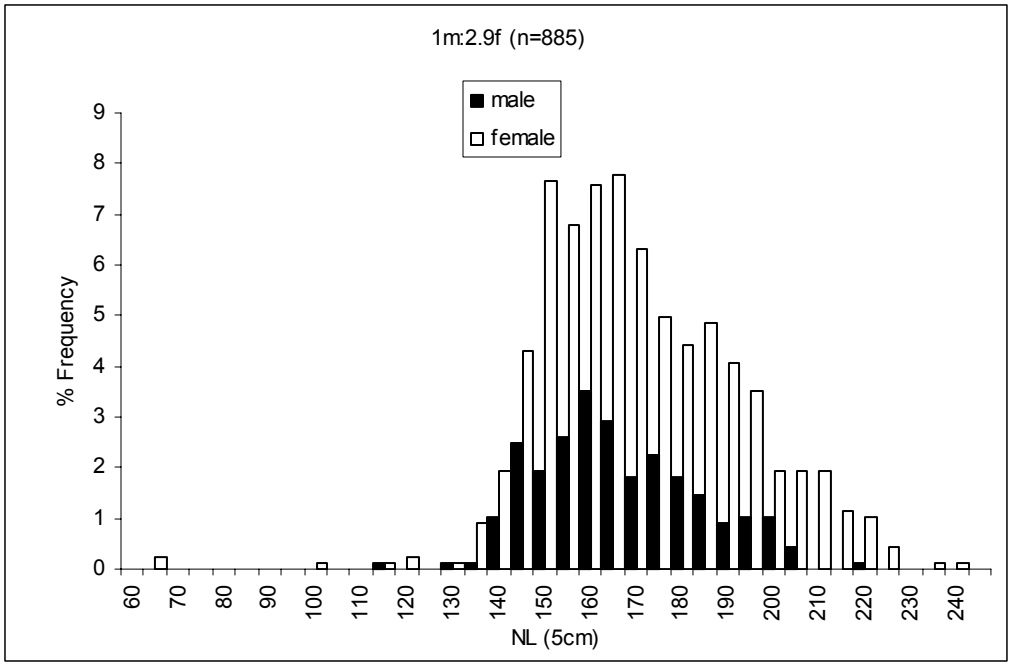

Figure 9. Length frequency and sex ratio of bronze whalers in central Namibia.

Of the 885 bronze whalers recorded for this project period in central Namibia only two sharks smaller than 100cm NL were recorded around Swakopmund namely one of 60 and one of 65cm NL (Fig. 9). The next size class recorded was 100cm NL. Catches showed that some near-term females do occur in the Swakopmund to Sandwich Harbour area but no specific pupping or nursery area could be identified. The size range of males is smaller (100-205cm NL) than that of females (100-245cm NL) but overall the size distribution indicate larger females than in the other two areas. This could indicate that females move into this area for pupping although no seasonal trend was observed.

Of the 2 395 bronze whalers tagged for the ORI programme, only seven were small (41-61cm NL) with the next size being 86cm NL. All seven were captured in the central area. For the NAFTAP programme 1 124 bronze whalers were tagged and of these only eight were small (43-60cm NL) with the next size being 75cm NL. Therefore one could ask where are the juveniles between 60 and 75cm NL if they are not in the central area (see Fig. 11).

In the nineteenth century, Sandwich Harbour was deep enough to be utilized as a harbour and it teemed with fish specifically sharks supporting a viable commercial fishery (Kinahan, 1991). However by the end of that century the lagoon silted up and all fishing stopped and it could not be used as a harbour anymore. The same happened with the Walvis Bay lagoon and if these were perhaps historic pupping and nursery areas in Namibia remain a mystery.

The sex ratio of 1m:2.9f might also indicate a breeding area possibly in summer at Sandwich Harbour. However, this sex ratio and the abundance of large females are more indicative of a pupping area. Unfortunately the sex of the 2 395 bronze whalers tagged for the ORI programme from 1984-2001 was not recorded and therefore it is impossible to compare historical sex ratios with the current ratio observed during this project.

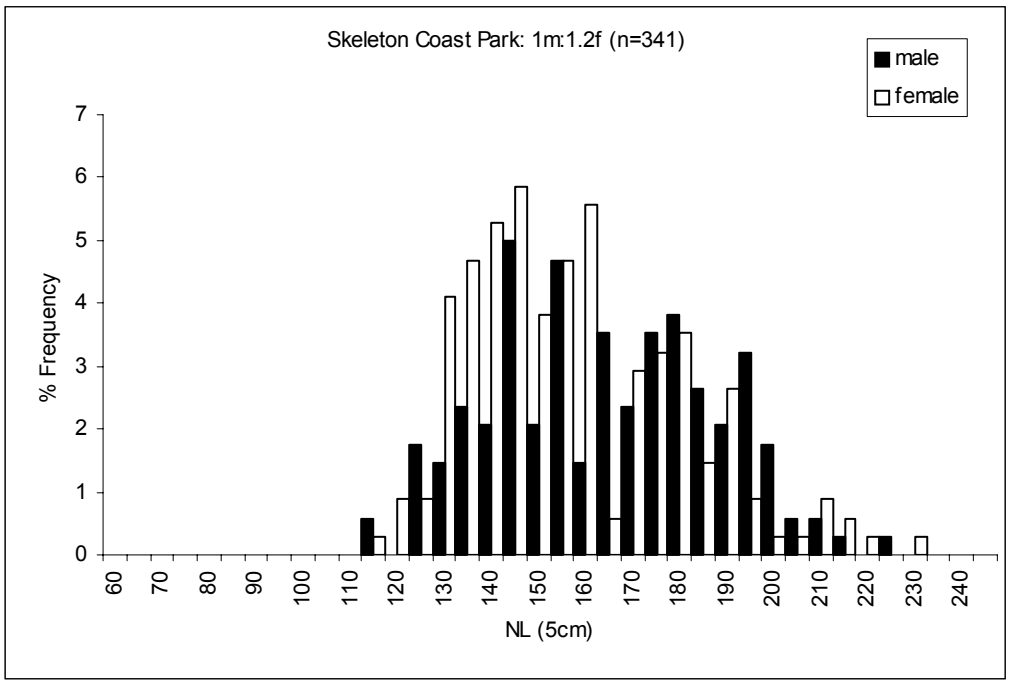

Figure 10. Length frequency and sex ratio of bronze whalers in the Skeleton Coast Park, Namibia.

In the Skeleton Coast Park (Ugab River to Kunene River) no bronze whalers smaller than 110cm NL were recorded. Males ranged between 115-225cm NL and females between 115-235cm NL. The paucity of females in the 160-170cm NL size range cannot be explained.

Except for Bosluisbaai which forms a large shallow sandy bay, there are other bays in this area but usually not with sandy shores. The sex ratio of almost one male to one female (1m:1.2f) indicates that it is highly unlikely the any breeding takes place here although one female (216cm NL) with breeding bite marks was observed in October 2004 at Bosluisbaai. It is therefore postulated that adult bronze whalers range between Baia dos Tigres and Sandwich Harbour seasonally for breeding and pupping and that the Skeleton Coast Park area acts as a migration corridor for adults.

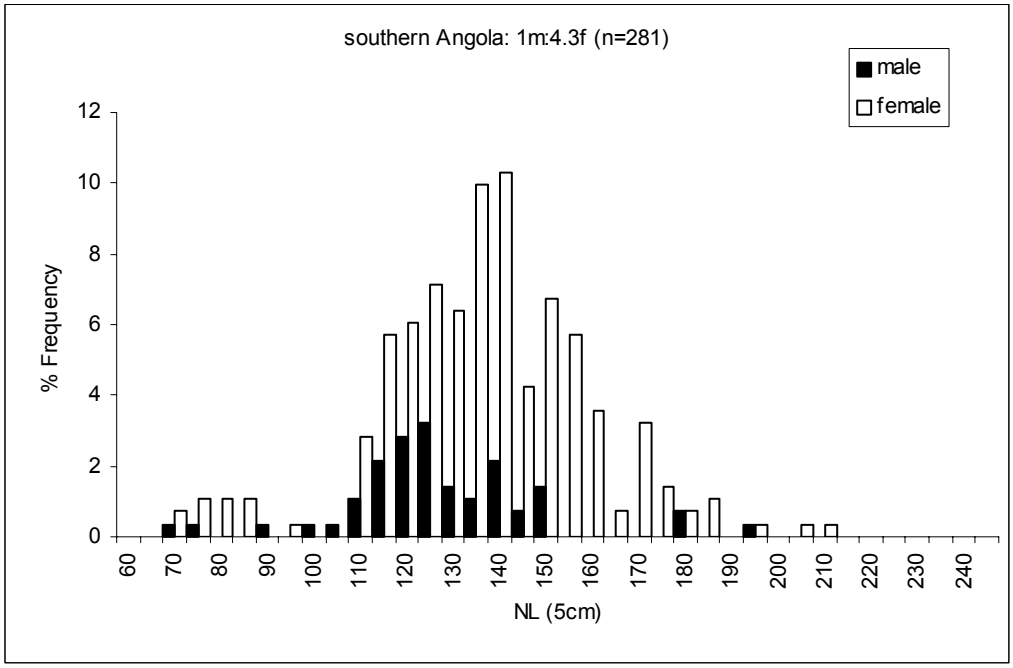

Figure 11. Length frequency and sex ratio of bronze whalers in the southern Angola.

Anecdotal evidence suggested that Baia dos Tigres might be the breeding, nursery and juvenile area of the Namibia/Angola population. A total of 281 bronze whalers were tagged in Angola between Baia dos Tigres and Flamingo Fishing camp during this project. Of these 17 juvenile bronze whalers (mostly females) less than 100cm NL were recorded which is indicative of a juvenile area (Fig. 11). The size range of males (70-200cm NL) are generally smaller than those in the other two areas. Therefore, it is suggested that Baia dos Tigres is a breeding area (possibly also a nursery area) and the area between Baia dos Tigres and Flamingo Lodge is a juvenile area for bronze whalers.

The sex ratio of 1m:4.3f strongly indicates that breeding also takes place here. It is however of importance to note that only middle-sized to smaller males occur here as compared to the other two areas. In the Skeleton Coast Park the full size range of males occur while in the central area it is also the middle-sized males that dominate. It can also be that the larger males were not present during the tagging surveys conducted there and that neonates were not available as our baits were too large for them to swallow.

4.7 Threats to habitat

Bronze whalers enter shallow water (Ayling and Cox 1982; Cappo 1992; Last and Stevens 1994) and also occur in brackish or freshwater in the lower reaches of large rivers and estuarine bays (Last 2002). The shallow coastal nursery areas of *C. brachyurus* are potentially vulnerable to habitat loss and pollution arising from coastal development in other parts of the world. The effects of this are likely to be greatest in parts of the Mediterranean Sea and East Asia. Expansion of marine aquaculture in New Zealand also potentially threatens nursery areas of *C. brachyurus*.

The breeding and juvenile area of Baia dos Tigres in southern Angola is situated in the Iona National Park. Since this is an unpopulated, desert area there is little fear of loss of habitat from the landward side. Loss of habitat here is a reality if shallow trawling takes place. The shallow bays at Tombwa and Namibe are situated close to densely populated urban areas and very shallow trek-netting takes place in these bays. It is assumed that bronze whalers would avoid these areas and rather use the safe haven of Baia dos Tigres for breeding and as a nursery area.

In central Namibia where heavily pregnant females do occur, habitat loss through urbanisation between Swakopmund and Walvis Bay is a reality. However, from Sandwich Harbour southwards the area is a closed nature conservation or diamond area right down to Oranjemund on the Orange River mouth. The coastal area from Meob Bay down to Chamais Bay is in the process of being declared a Marine Protected Area (MPA). No fishing is allowed in a MPA. This will at least offer protection of shallow habitats from Meob Bay to Lüderitz. However, from Lűderitz southwards, shallow diamond mining and marine dredging has altered the shallow habitats for all marine organisms. Not a single fish, shark or skate was caught when this area was surveyed in April 2007.

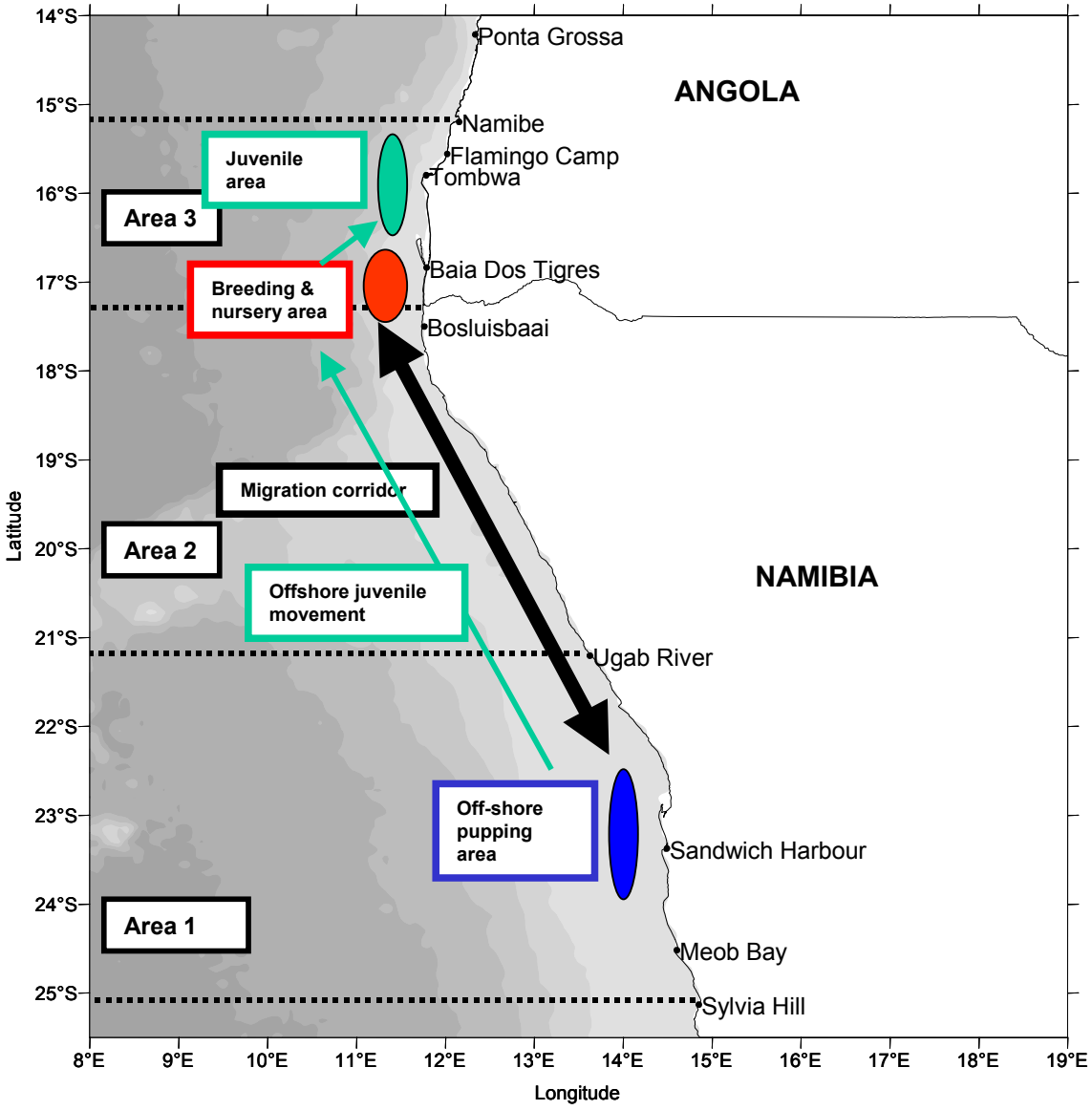

Figure 12. Seasonal movements and reproductive behaviour of bronze whalers between central Namibia and southern Angola.

Figure 12 shows the seasonal migration of adult bronze whalers for breeding and pupping (tag-recapture results from previous chapter), and the hypothetical movement of neonates from the pupping area to the nursery area and then into the juvenile area.

It is hypothesized that pups are born offshore in Area 1 probably close to shallow reefs. They immediately start feeding and have to fend for themselves. The neonates most likely stay in this area until they reach about 60cm NL. It is then assumed that they slowly move northwards with the current, through Area 2 until they reach the nursery area of Baia dos Tigres where there is plenty of food in the shallow bay (Area 3). They would probably stay here until they have reached about 75cm NL. At this size they probably move further north into the juvenile area where they would stay for some time until they become sub-adults or reach sexual maturity. They would then return to Baia dos Tigres to breed. As adults they would start participating in the seasonal migration to central Namibia (Area 1).

4.8 Conclusions

- The presence of heavily pregnant females and the abundance of large females in mid-summer in central Namibia suggests that the pupping area might be offshore in the vicinity of Sandwich Harbour. No neonates were observed in the shallow Sandwich lagoon which would be a perfect nursery area.
- Neonates (40-60cm NL) possibly move northwards with the current until they reach the nursery area of Baia dos Tigres.
- At about 75cm NL they possibly move further north into the juvenile area where they stay until they reach sexual maturity.
- They then move back into Baia dos Tigres for breeding.
- The adults would then take part in the seasonal migration towards Sandwich Harbour. The Skeleton Coast Park (Area 2) serves as a migration corridor for this movement.
- Habitat loss through degradation (shallow trawling), diamond dredging and urbanization could have an effect on breeding success in central Namibia and southern Angola.

5. The Dynamics of the Bronze Whaler Fishery off Namibia

5.1 Introduction

The line fish (angling fish) resource in Namibia is shared by two different sectors. One is the recreational sector which includes shore-based rock-and-surf anglers (including competitive sport fishing) and some recreational skiboats. The other is the commercial sector which includes the lineboats and commercial skiboats (Holtzhausen et al., 2001). The linefish fishery as a whole has been extensively and statistically investigated for its socio and economic benefits to the country in the last decade (Kirchner, Sakko & Barnes, 2000, Zeybrandt & Barnes, 2001, Barnes, Zeybrandt, Kirchner & Sakko, 2002, Barnes, Zeybrandt, Kirchner & Sakko 2004, Kirchner & Stage. 2005). Batty, Tjipute & Shapi (2005) for the first time also considered the social and economic benefits of the marine artisanal fishery in Namibia. All these investigations were carried out covering all stakeholders and included all linefish fish species of importance. None of these investigations therefore concentrated solely on one species from one fishery such as the bronze whaler sport fishery. Therefore, this investigation could not be carried out using the complex methodologies used in the above-mentioned surveys but is rather based on facts gathered from interviews with angling guides which were then extrapolated to get an estimate only of the economics of the bronze whaler sport fishery.

A survey was thus conducted to determine the economic and social benefits specifically of bronze whaler guided angling tours to the Namibian economy. Full-time and part-time angling guides, tackle/bait shops owners and accommodation establishments catering for the angling market were physically interviewed at Walvis Bay, Swakopmund and Henties Bay.

5.2 History

About one quarter (382km) of Namibia's coastline of 1560km is open for recreational shore angling and is historically famous for its abundance of angling fish species and also inshore shark species. Local and foreign anglers, mostly from South Africa, frequented this coastal area since the 1960's mostly during the summer months when shore angling is normally at its best. Using 4x4 vehicles they fished on their

own at the best fishing spots along the beach. During fishing competitions, sharks were the preferred target as they would earn the competitor more points per effort than targeting the smaller angling fish species. Because of its size and fighting ability the bronze whaler was and still is the ultimate prize for recreational or competitive angling in Namibian waters.

In 1993, three years after independence two expert Namibian anglers (both regional club competition anglers) saw a potential business opportunity in the tourist market and started the first guided angling tour operation from Swakopmund. They would take paying groups of 4-6 anglers fishing for a day along the beach targeting sharks or angling fish or both, depending on the client's preferences. They expanded their operation to include angling from close to shore. As their operation expanded more angling guides entered this rapidly growing enterprise and currently between 12-14 angling tour operators have their businesses set up. Shark angling tours, specifically targeting bronze whalers along the Namibian coast, have thus become increasingly popular over the last decade and have become an established part of the local tourist industry at the coast.

In addition Swakopmund started catering for adventure seekers and it is now world-famous for its quad bike operations, sand boarding, tandem skydiving, camel & horse trails, paragliding, hot air ballooning etc. Overland budget tours have made Swakopmund their destination of choice specifically as they cater for the younger adventure seeker. These activities had made Swakopmund the ultimate adventure centre at the coast, boosting the local economy specifically the accommodation and entertainment businesses.

5.3 Client Profile

United Kingdom

The majority of the foreign anglers who come to do shark angling are from the United Kingdom (UK) and tend to be middle-income earners and tradesmen. According to the guides interviewed the upper income-earners in the UK are marlin anglers and Namibia has not yet managed to make any inroads into this exclusive market. Mainly men, the UK anglers who come to Namibia tend to be trades people or own small businesses and travel to Namibia solely to do shark angling from the shore. The majority of the UK anglers are English and the second largest group is from Scotland. The UK tourists presently still only come to fish and do not bring their partners or

families along and they spend their entire vacation shark angling. Anglers interviewed said their partners/families took a holiday at the same time but went elsewhere in the world. A father and son from the Isle of Man interviewed at Sandwich in March 2007 had come solely to do shark fishing, while the mother and daughter were on a safari in Kenya. This was their first trip to Namibia, having heard about the excellent shark angling from the shore from a friend who was accompanying them on his second trip to Namibia. They knew very little about Namibia and were not aware that various companies and establishments offered safaris which compared favorably to what is on offer in East Africa.

Germany

By contrast the German tourist who tends to come to hunt, comes to fish as well and they tend to bring along their partners extending the hunting trip to a fishing and safari holiday. These tourists combine their sport with a short holiday in Namibia. After spending a few days on a hunting farm they come to the coast for a day or two. The hunter will then go angling for a day while his partner explores Swakopmund and surrounds. Namibia has long benefited from German tourists and the people offering hunting safaris have very successfully included shark angling as an add-on extra to their business. Most of the hunters who come for two weeks tend to spend at least one or two days angling. Anglers however still only come to fish and show little interest in hunting or photographic safaris.

Eastern Europe

Russian and Hungarian shark anglers are small but growing markets. Three of the guides interviewed said that they were receiving increasing numbers of anglers from these countries.

Belgium

A small group of French and Belgian anglers are also coming to Namibia to catch bronze whalers. Belgian entrepreneurs who have business interests in Namibia target this latter group of tourists. They advertise in Belgium and France and bring tourists out for two weeks to hunt and to do shark angling. These tourists stay on farms co-owned by the Belgians for their hunting and then spend time at the coast in an establishment also co-owned by the foreign entrepreneurs.

A small group of Swedish, Dutch and Swiss anglers also come to do bronze whaler angling. Namibia has strong political ties with Sweden which predates independence

and Sweden has until this year (2007) funded many bilateral development programmes in Namibia. Namibia opened an embassy in Stockholm at independence and tour operators need to market their tours and services in Sweden using the services of the embassy. The Swedish market is a potentially lucrative market and guides have done little to promote their angling tours to this market, relying on word of mouth and rebroadcasts of television programmes made by Swedish TV stations about the bronze whaler along the Namibian coast 10 years ago. The largest number of anglers from Sweden comes as a result of seeing the broadcast of television programmes or because they have been to Namibia as a result of working for SIDA. With Sweden closing its embassy in Windhoek and ending all bilateral development cooperation in 2008, contact with this Nordic country will diminish and guides need to market their tours (Press release, 21 January 2007 – Swedish Ministry of Foreign Affairs, www.sweden.gov.se).

USA

One of the angling guides interviewed has joined up with businessmen from diverse sectors of the Namibian economy to form a company that will market their combined businesses in the USA. A representative group from these businesses is on their way to the USA in August this year to introduce their business to the Presidents of the Hunting Association and Angling Association in Springfield, Illinois, amongst others. The Namibian business group decided to target the Americans because there are 17 million anglers and 23 million hunters in the USA. With the stable political situation in Namibia this will be an ideal tourist destination for the American tourist who since 11 September 2001 has become increasingly more careful about selecting holiday destinations. An American tourist booking a package with a tour company in this group will then automatically receive brochures and material advertising the businesses of the other group members.

South Africa

The South African shark angling market is also showing signs of expanding. The South African shark anglers who come tend to be corporate clients being entertained by a company for a few days. Most of these clients are not anglers and it is hoped that after the initial experience they will return with a group of friends to do shark angling. This is a potentially lucrative market because they are all high profile earners and if targeted properly could be of great benefit to the tourist industry as a whole. If one could market Namibia successfully while they were here for the initial shark

angling they could return within 18 months with friends and family to have a truly Namibian holiday.

5.4 Profile of Angling Guide

Most of the angling guides fall in the age group of between 25 to 40 years old. They all are in peak physical condition as this profession demands hard physical work. Most guides are married with some of the younger ones being unmarried. Some of the more successful guides work a 6-day week while some of the less experienced guides work less days in a week. Some guides have combined their fishing activities with safaris to Etosha National Park or other destinations in Namibia and even to southern Angola.

Depending on what has been agreed on with the clients beforehand, a typical shark angling day will start at about 08H00 when the guide will fetch his clients from their hotel. He will then take them first to a suitable fishing spot to catch fresh bait such as spotted gully sharks (for gills and liver) or angling fish such as kob (uses the head). The guide will prepare each client's fishing tackle for him such as baiting it and then in most instances he will also cast for him or her. After collecting enough bait, the guide will pack the vehicle again and drive to a suitable fishing spot for bronze whalers. Depending on the results, they will keep looking for suitable spots until they find the sharks. The guide will attend to every fishing need of e.g. novice anglers and he might even reel in the shark for them if need be.

At lunchtime, the guide will provide his clients with lunch packs and beverages or even a barbeque on the beach. Normally the guide will return his clients before sunset to their hotel. He will then go to a fish-cleaning place where he will clean the fish that his clients caught and also pack and freeze it for them. The guide then still has to clean his vehicle and all the equipment such as rods and reels, and prepare everything for the next day. Early the next morning the guide buys bait for the day (eg. pilchard with which to catch kob), collect the lunch packs and beverages and then collect the anglers from their hotel. If there are new clients, fishing permits must be bought for each of them and he will also take them to a tackle/bait shop where they can buy personal items such as booties, hats, sunglasses etc. A normal working day for an angling guide runs for 10-15 working hours.

It is interesting to note that none of the guides interviewed had considered angling guiding as a first profession. All of the guides either still had another income generating profession or had worked in other fields before turning to guiding. For angling guiding to take its rightful place in the Namibian economy, guides need to take a fresh look at their profession and formulate a standard that all guides aspire and adhere to. All professions benefit from codes and standards. Guides interviewed were wary of formal bureaucratic bodies seeing them as conservative watchdogs. However a formal body representing guides will ensure that no unscrupulous, dishonest or bad angling guides will operate in Namibia. At present all the guides are good anglers and good hosts but anyone with the equipment and the right vehicle can currently take out tourists and such people will harm this fairly young tourist industry.

5.5 Forming an Association

Although the guides interviewed are professional, good shark anglers themselves and excellent hosts it is clear that they are not yet maximizing the full potential of the market. No formal angling guide association exists and guides currently operate on their own. The majority of the guides are registered with the NTB (Namibia Tourism Board) but do their own marketing, advertising and planning. Presently at the coast there are at least 12 angling guides most of them working full-time. A few part time guides work in other professions and do guiding part-time.

A formal association of guides would be able to reach a wider global market, do more effective planning and advertising. At present all the guides know each other and generally work well together. Although the NTB checks on vehicle insurance, vehicle roadworthiness and first aid certification there is no formal angling body which checks on those guides who are not registered with the NTB. There is also no formal body that checks on angling guiding ability. The potential damage to the industry as a whole and Namibian tourism in particular is staggering if an unregistered guide without any insurances has a vehicle accident in which a paying foreign angler is injured. Registered guides were generally not concerned about unregistered part-time angling guides and often pass work on to them. Only two of the guides were not keen on using unregistered people as they felt it harmed their business. Both these guides were also not keen to employ guides because they felt that a good angler did not necessarily have the skills to be a good host/guide. Most of the guides were not

keen to serve on a body representing the industry because they felt they do not have the time and do not want to be seen as a watchdog in their profession.

Guides complained that the NTB and other overseas Namibian tourist operations do little to promote angling in Namibia. Yet the NTB cannot be blamed for not promoting the angling tours if nobody makes presentations to the NTB on behalf of the angling guides. A formal association will have a greater voice and will be able to address effective marketing strategies which will benefit all guides. Accreditation of guides will assist potential tourists who use the internet or angling magazines to book an angling safari. Most of the internet sites and magazine advertisements indicate that the guides practise tag-and-release as part of the fish tagging programme of the Ministry of Fisheries and Marine Resources. Though there are hunting farms advertising the tag-and-release programme they use professional guides who are part of this programme. However there are guides advertising tag-and-release who are not part of the programme. Accreditation would solve this problem. Incorrect advertising and marketing, which is not checked and addressed, will start to have a negative economic impact on the angling industry. Although Namibia has some of the best shore-based shark angling opportunities in the world, foreign tourists will lose their trust in the entire Namibian tourism industry if they are fed misleading information.

5.6 Destination of Choice

Namibia is the destination of choice offering shark angling tours from the shore and this together with an almost 100% success rate of catching a bronze whaler makes Namibia the number one bronze whaler angling destination. Articles about shark fishing in British magazines confirm this success rating with article after article confirming that the writers were initially sceptical about the claim of the fishing but by the end of a week when they had caught not one but a few bronze whalers they all confirm that Namibia is the best shore-based shark angling destination. Australia and Florida both offer shark angling but neither of them offer shark angling from the shore.

Apart from the pre-booked angling tours from the UK and Europe, guides also get a few angling tourists from local accommodation establishments and local companies selling tourist activities. A fair percentage of self drive tourists go shark angling and a small group of backpackers are eager to try shark angling. One of the guides interviewed encouraged backpackers on a tight budget. At N$600 per person for 8

hours angling his price compared favourably to other companies offering sandboarding and quad biking tours for N$300 for two hours. He is one of the younger of the guides and obviously has a natural rapport with the younger backpackers. This method of targeting the backpacker market is a good entry point for younger guides starting out in this competitive market.

Namibia is not a destination of choice for most of the UK tourists. High travel costs, a relatively new tourist history, no direct flight routes (until very recently) made Namibia a second option. Cheap package holidays to various exotic locations are offered on websites and newspapers in Britain. Partners of British anglers either go on one of these package holidays offered or when they go on a more expensive safari holiday, they tend to go to ex British colonies such as Kenya. The Namibian angling guides have been very successful at attracting the UK shark angler but they need to do more to attract the partners to also come to Namibia. They also need to do more to ensure that the anglers come for longer periods, doing more than just angling. The diversification will ensure that a wider section of the Namibian population benefits economically. Although the British pound is strong and it allows more British people to travel than before, Namibia remains an expensive destination. The group who come to Namibia are lured by the magnificent shark angling and not because this is a cheap holiday. This means that as yet very few do any other activity in Namibia. Those that come to fish generally are not in an economic position to add an extra week to include hunting, safari or any other activity inland. The fluctuation in the strength of the Namibian dollar to the British pound also has an effect on the amount of British tourists who book angling tours. One of the angling guides based in Walvis Bay, confirmed that the exchange rate fluctuation has a direct effect on the angling tours booked from the UK.

The British angler now has a choice of three direct flights to Namibia per week with Air Namibia having reintroduced this direct route. This direct flight is a great asset to the angling industry because it cuts the travelling time from the UK to Namibia dramatically. Anglers from the UK previously had to fly via South Africa or Germany and catch connecting flights to Windhoek. The guides have voiced a desire for direct flights to be introduced between the UK and Walvis Bay that will really benefit the angler. The direct flight to the coast will potentially add an extra day to the angling tour. Adding an extra angling day to a very tight schedule will obviously benefit the guides and the coastal economy.

5.7 Competitive Angling

Four national angling competitions take place annually in Namibia during which 120 competitors take part in each competition. To take part each angler needs to buy 10 meters of steel trace, bait, hooks, strops and sinkers costing ±N$235. In addition to these competitions there is a 3-day national championship in which seven angling clubs take part. Each of the clubs sends 6 anglers and a few reserves adding to a total of 50 anglers taking part in the championships. These anglers also need to buy tackle. Added to the above, four angling coastal leagues also take place in which 60 anglers take part in each event.

Apart from these competitions the ordinary angler wanting to catch bronze whalers has to spend money in the tackle shops to equip him. Tackle shop owners confirmed that young men in particular are keen to experience bronze whaler angling. The total annual income of the tackle shops generated from sales to the competitive anglers and the recreational anglers was estimated at N$380 000.

5.8 Boosting Local Economy

Angling tackle shop owners interviewed all acknowledged that the shark angler was a very valuable customer. Although the angling guides provide all the equipment and tackle, the angler needs to buy some very basic items before they go out on their first day. Booties are an essential but often they need big hats and sunglasses as well. The average UK angling tourist spends a minimum of N$500 on angling equipment and accessories, but they also very often buy a reel (± N$1000) and other tackle. On the other hand German tourists tend to buy only the barest minimum. Shop owners proudly display photos of their clients and are able to point out foreign anglers who return to fish every year and support their business. A tackle shop owner did complain that some of the guides bought all their own equipment abroad and not from Namibian shops.

The increasing tendency to buy equipment and goods over the internet has also benefited Namibian firms who actively sell tackle on the web. One Henties Bay firm sells shark tackle in Angola and wants to expand an obviously lucrative market. Angolans needing equipment and tackle used to order from American catalogues but buying from the Namibian website means they are able to get their goods quicker

and cheaper. This firm also makes custom made fishing rods and employs Namibians in this new enterprise.

Accommodation establishments at the coast benefit greatly from the shark anglers. An average week during the peak season will see between 200 – 400 beds needed by the anglers. Many of the guides have negotiated preferential rates with accommodation establishments for their anglers. Yet the tourists who book through guides can benefit the accommodation establishments in Walvis Bay, Swakopmund and Henties Bay by between N$367 500 and N$700 000 a week. Many guides interviewed mentioned that shark anglers used to be accommodated in Walvis Bay and Henties Bay but many anglers now prefer to stay in Swakopmund because of the restaurants and pubs which are world class and well priced. UK tourists in particular enjoy a pub culture and prefer the Swakopmund nightlife to what is on offer in either Henties Bay or Walvis Bay.

Flights arriving into Namibia from abroad arrive in Windhoek early morning and most of the anglers immediately transfer to Eros airport and fly to the coast or take the bus or shuttle service. This means that only the coastal accommodation establishments benefit from the anglers and very few anglers overnight in Windhoek. Two Swedish anglers interviewed in March said they had hired a sedan car at Windhoek International Airport in the afternoon when they arrived from Sweden via Johannesburg and immediately drove through the desert heading for the coast not to miss their next morning early appointment to go shark angling. Arriving late in Walvis Bay they were ill equipped for the harsh Namibian sun the next day. Neither the sun nor the long flights could dampen their dream to land a bronze whaler and it was a delight to see the elder of the two catch a bronze whaler after an hour's 'fight' in the late afternoon.

Most of the anglers stay in cheaper Bed and Breakfast establishments and after a day out along the coast spends a few hours in the local pubs and restaurants. One of the guides uses a Dorking, Surrey (UK) based angling shop to book tours on their behalf. This particular angling shop only uses one of the top accommodation establishments in Swakopmund, which has rooms from N$500 per night. However, when the anglers return they tend to ask to be placed in cheaper accommodation. One of the angling guides based in Henties Bay offers accommodation on their premises but generally guides do not run accommodation establishments as well as angling tours.

All the guides make provision for breakfast and or lunch on the beach. This is either a barbecue on the beach and/or a food parcel. The barbecue is prepared on the beach by the guide or an employee and the food parcel is bought from one of the local catering establishments. This is included in the daily rate and financially benefits the catering establishments. Although no catering establishment specifically targets these angling tours, as this market expands the potential exists for a company to offer different catering options.

5.9 Marketing

Angling guides interviewed work either full or part time as guides and are based along the coast at Walvis Bay, Swakopmund and Henties Bay. Professional guides who rely solely on angling tours for their livelihood became pro-active about 5 years ago and started targeting formerly untapped foreign markets. Although a few British anglers came to Namibia specifically for shark angling, the UK market was small and one of the guides spotted a niche in the market and invited Peter Petzell of World Wide Angling to Namibia for 3 days to do bronze whaler angling. As a result of this trip the British Beach Shark Angling Classic was held in Namibia the following year. 42 (forty two) foreign shark anglers came to Namibia for 14 days to participate in this event. This angling classic with the accompanying media attention opened the doors to the lucrative UK shark angling market. TV documentaries by John Wilson for Discovery Channel and Henry Gilbey at the same time meant that shark angling along the Namibian coast was introduced to a formerly untapped market in Europe. Repeat screenings of these shark-angling programmes on television in the UK and in Europe have continued to attract first time shark anglers to Namibia.

Television documentary programmes on shark angling in Namibia, filmed almost 8 years ago by a Swedish based company, also continue to benefit the Namibian shark angling industry. A father and son from Stockholm, who were interviewed at Sandwich Harbour during March 2007, mentioned that the son had seen the bronze whaler programme on Swedish television at age 6 and made his father promise to take him shark angling when he turned 14. March 2007, 8 years later, they were on the beach at Sandwich Harbour angling and were lucky enough to catch their first bronze whaler on their first day out angling.

Tour operators in Namibia have also started using the Internet medium to market their tours. Websites are becoming increasingly sophisticated and the Namibian operators are aware that they are competing for tourists in a global market. Websites hoping to attract hunters from Europe almost all indicate that they offer bronze whaler angling tours. These websites also mention that they are participating in the fish tagging programme of the Ministry of Fisheries and Marine Resources,, knowing that an increasing number of anglers are keen to be part of such scientific programmes. The hunting guides, keen to expand their market, work closely with the angling guides and advertise shark angling but do pass angling enquiries on to the appropriate angling guides. Websites aimed at promoting Namibian tourism and local tourism operators actively promote and sell bronze whaler angling tours.

The angling industry for a long time was almost solely dependent on Southern African tourists and the new target markets, global advertising, television programmes has changed the face of the industry. Magazines aimed at targeting the angling community also carry advertisements and articles on shark angling along the coast. In May 2007 a Tourist Expo was held in Windhoek at the show grounds allowing all those involved in the tourist industry to have a stall advertising their operations. Not a single angling guide from the coast was present. None of the guides were interested in advertising their tours at the expo as they felt it was targeted at the local market which is too small for them to invest money in.

Some angling guides have successfully marketed their business in overseas angling magazines such as in Sea Angler (UK), Sea Fishing (UK) and Rute & Rolle (Germany). Some of the headlines in these international angling magazines featuring excellent articles on bronze whaler angling are quite descriptive such as “Climax Coast” (Sea Angler), “When the sharks bite” (Sea Angler), “Big-game beach fishing” (Sea Angler), “Shark rocks the record” (Sea Angler), “Shore sharks” (Sea Fishing), “Mission accomplished” (Sea Angler), and finally “Monster sharks in Namibia” (Rute & Rolle). See Annex.

All the articles mention the incredible coast, the stunning angling conditions, the excellent professional guides and the legendary Namibian hospitality. Most of the writers were sceptical when they heard about the angling conditions before arriving in Namibia but after the their first day along the shore catching the ultimate fighting fish they were all convinced that the Namibian coast was one of the most stunning angling destinations in the world.

5.10 Revenue

The majority of the full-time Namibian angling guides (10) interviewed were fully booked for at least 200 days a year while many of the more experienced guides are fully booked throughout the year. Although the majority of the guides are not fully booked (in advance) for twelve months a year they do work during the quieter months and take “walk in” clients and also take tourists out on dolphin cruises, hunting or on photographic safaris.

The figures were all obtained from the guides themselves and it was difficult to incorporate all data in calculating the total revenue to the Namibian economy. Therefore two scenarios are considered as follows.

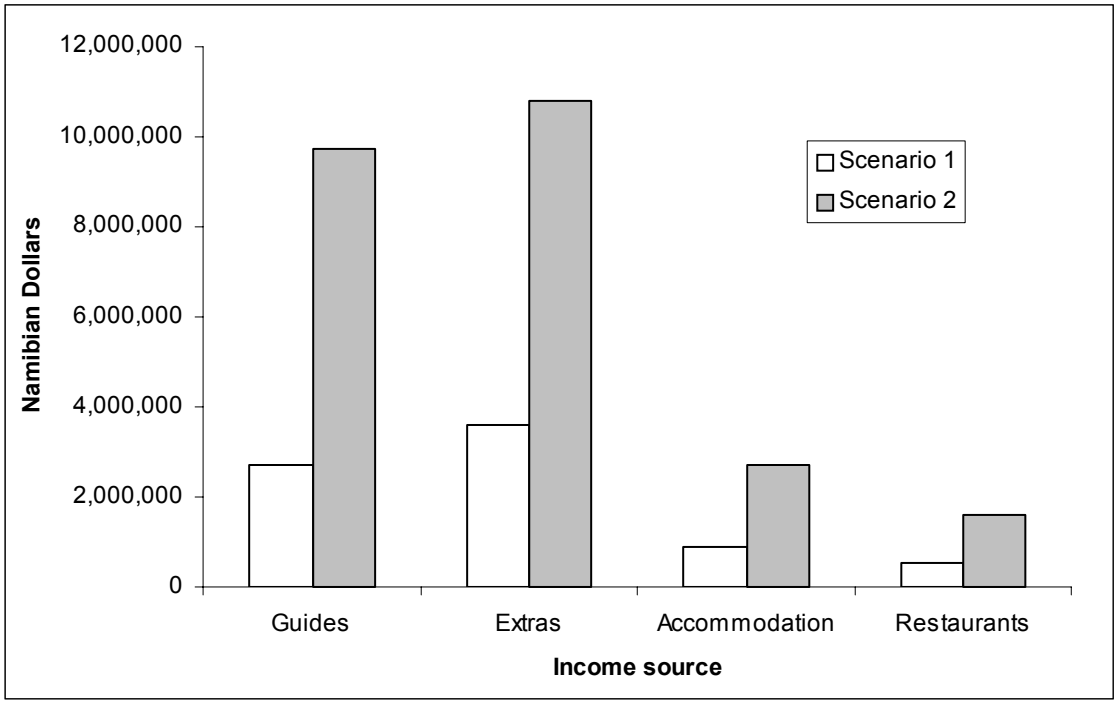

Figure 12. Graph indicating revenue that is, or could be, earned through various sources in the Namibian bronze whaler angling fisheries. Scenario 1 indicates the current situation and scenario 2 indicates potential revenue that could be earned.

Scenario 1: N$8 million (excluding flights)

This scenario depicts the current state of revenue earned through the shark angling fishery in Namibia. Totals used here are average figures obtained during interviews with 10 angling guides. The scenario is based on 10 fulltime angling guides, each

catering for 3 clients per day for a total of 200 days per year, at an average cost of N$750 per client per day. This means that at least 6000 foreign anglers visit the coast annually and 60% of these (3600 anglers) come solely to catch a bronze whalers. The more experienced and well-known guides charge a daily rate of between N$800–900 per client, while for the younger and less established guides it varies between N$600–750 per day. Using these figures the average annual turnover of the angling guides, generated from clients targeting bronze whalers only, is N$2 700 000 or N$270 000 per angling guide,.

All these foreign anglers stay in accommodation establishments at the coast at the minimum daily rate of N$250 per person. These establishments earn at least N$900 000 from the bronze whaler anglers only. The additional benefit to the restaurants and pubs at the coast from the shark anglers added another N$540 000. This figure was obtained by assuming that each evening the anglers visited a restaurant, hotel or pub and spent an average of N$150 per person. In addition to the guide fees, accommodation, restaurants and pubs all of the anglers spent money at the tackle shops (sun cream and hats or sunglasses), bought presents and souvenirs for family and friends back home to the value of at least N$1000 each. This adds an additional N$3 600 000 to the coastal economy.

Currently, the bronze whaler angling tours, angling competitions, accommodation establishments that cater for the angling tourists, coastal restaurants, angling permits, tackle shops and other souvenir shops all adds a minimum of N$7 740 000 to the Namibian economy annually.

Scenario 2: N$25 million (excluding flights)

One successful, experienced angling guide, charging a top fee of N$900 per day, can generate a turnover of approximately N$810 000 from shark angling alone. At present there is only one guide who can command this fee and who is consistently busy for at least 300 days per year. A proven track record and consistently high standards means this guide is fully booked at least a year in advance. Therefore in this scenario it is assumed that all the existing guides could expand their client base and work for 300 days each year at a fee of N$900 per client per day. This means that at least 18 000 foreign anglers could visit the coast annually and if 60% of these came solely to catch a bronze whaler the potential revenue to the Namibian economy could be a staggering ± N$25 million. Using these figures accommodation establishments would benefit to the sum of N$2 700 000 while restaurants and pubs

could earn at least N$2 1 700 620 000. The extra revenue earned from presents, tackle and other sundries could add up to N$1 620 000. This scenario reflects the incredible potential of bronze whaler angling to the Namibian economy.

This figure excludes flights and travel costs which would add another N$28 602 000 million (scenario 1) and N$85 806 000 (scenario 2) if Air Namibia was the sole carrier for all the foreign shark anglers. The majority of the anglers (UK clients in particular) use Air Namibia but as there are at least three airlines flying to Namibia from Europe we have not included travel costs. Currently the flights to Namibia cost the UK angler £700 (N$9 80011 339) with transfers from Windhoek to the coast. UK anglers interviewed said the total cost of a 14-day angling trip to Namibia cost them ± £2000 (± N$29 000) of which flights to and from Namibia formed a substantial part of this cost. If Air Namibia was the sole carrier for anglers the total benefit to the Namibian economy would be substantially more than the conservative figure quoted above.

These figures do not include the 'add on' value of other activities that bronze whaler anglers could add to the economy. These could include hunting, camping safaris, sight seeing tours and other adventure activities at the coast and inland. Working together in an association and realising the value of their unique industry should give the guides an incentive to do collective advertising and marketing. It should also encourage them to form an association to protect this unique Namibian fishery.

This economic survey does not include any data or figures for Angola. Some Angolan angling guides (Flamingo Lodge and Kwanza Lodge) were contacted to take part in this survey but unfortunately none responded. As the shark angling tours are a lucrative income earner one can only assume they want to protect their markets.

Angola is a country recovering from a civil war that destroyed the tourist industry and it remains a difficult country in which to travel and work. Namibian guides need a permit to operate in Angola and while many of them would like to work along the coast offering shark angling tours, the majority of Namibian guides go to Angola only as angling tourists.

One of the most successful Namibian guides worked for 4 years in Angola (not as a fishing guide) but does not take tours into Angola, preferring to go on his own to target sharks and other angling fish as a tourist. Namibian angling guides have taken tourists to Angola to fish but most guides indicated that until the economy and

tourist market in Angola changed, they would not take advantage of this new market on Namibia's doorstep.

5.11 The Way Forward

The need to protect and to expand the shark angling market in Namibia is essential. Presently 12 – 14 guides conduct shark angling tours along the Namibian coast with a few of the guides taking shark anglers to Angola from Namibia. On average the guides take between 50 – 60 angling groups out per year. Group sizes vary but tend to be 3 – 4 anglers. A few part-time guides (not included in these calculations) have larger groups of 10 – 12 people for longer periods of up to two weeks a few times a year. The average group of 3 – 4 anglers usually comes for one week during the busier Namibian summer season, which extends from October to the end of March. Guides tend to be booked a year in advance during this period but during the quieter period of May – September they focus on shorter angling tours of one or two days. These shorter tours are usually part of a hunting package and the anglers are generally European.

The established guides who market themselves overseas and have an excellent reputation are fully booked throughout the year but the majority of the guides indicated that they have a quieter period during the Namibian winter when the sharks are more abundant in Angolan waters. During this period a few of these guides diversify their activities and take tourists on day safaris, dolphin cruises, safaris to the Etosha National Park etc. There are a few angling guides who are booked for the entire year as a result of their excellent reputation but these guides do not depend solely on shark angling. These guides also do boat and shore angling tours for edible fish.

Guides need to study the global tourist market and to actively target different countries to ensure that a stable market exists throughout the year. During the interviews guides continually mentioned that "the bronze whaler is the poor man's marlin". This is evident in the profile of the main shark angler, the British male tradesmen. These tradesmen rely on the strong British pound that allows them to travel to Namibia. This means that this angling industry is very depended on world economic stability and growth. Economic depressions tend not to affect the wealthy but have a great impact on the lives of the middle class earner across the world. Expensive holidays to Namibia to do shark angling will not be affordable to the

average tradesmen in a world economic slump. In the UK the trades people are the first to feel the effects of an economic depression as the construction industry is generally the first industry to slow down.

The angling industry therefore needs to actively target other growing markets and a wealthier tourist. The bronze whaler angling guides need to change the minds of people about their valuable "product". Successful and skilled advertising abroad can for instance change the image from "the poor man's marlin" to the "Skeleton Coast's toughest fighter".

As guides currently operate independently and without any formal representation on a board that meets to discuss strategic issues that can affect their work, little is done to protect this industry. Guides claim they do not have the time to work on different marketing techniques but they acknowledge that strategic planning is essential. Working closely with skilled advertising and marketing professionals here and abroad to change the image of the bronze whaler angling fishery is a first and crucial step in ensuring the growth of this industry.

Environmental concerns twenty years ago were the concern of a select few but the effects of global warming, industrial pollution, and deforestation etc. have now made ordinary people conscious of the need to protect the environment. Marketing the benefits of taking part in the tag-and-release programme of the Ministry of Fisheries and Marine Resources along the Namibian coast and going home with a photo to prove they were part of this project will give anglers a belief they are adding to scientific research which will add to our knowledge about the bronze whaler and other sharks.

It was evident from the interviews that Namibian angling guides are excellent angling guides and have a good reputation abroad and locally. The anglers rebook most of the guides year after year and the angling guides continue to receive new business by word of mouth. Namibia's excellent shark angling reputation is due partly to the excellent fishing conditions along the coast but also largely to the work and effort done by these dedicated guides. All the guides work independently and run their own businesses. They do all the bookings, are responsible for their own administration, and do all the angling themselves. This leaves little time for strategic planning.

Young, first-rate guides interviewed had to rely on charging slightly less than the more established guides and have to rely on other work and diversify their tours to attract clients. These guides already have their regular clients but do not have marketing skills to enter the profession on a full time basis.

Bronze whaler angling is a lucrative and important part of the Namibian tourist industry. The potential exists for this industry to expand and attract a valuable tourist who will benefit the wider tourism market. For the full benefits to be felt throughout the tourism industry in Namibia, angling guides need to work in cooperation and consider potential pitfalls and new markets. This particular angling fishery is very reliant on shark availability and currency fluctuations. As a fairly young sector of the tourism industry it needs to ensure that angling guides are all offering a similar standard of service, striving to attract the client's partners as well and thereby ensuring that the clients spend more time in Namibia.

5.12 Conclusions

Namibia

- Bronze whaler angling tours from the Namibian shores are a valuable income earner for the country, earning currently at least 8 million Namibian dollars annually (excluding flights). The potential exists to expand this market by attracting more anglers but also to have the existing anglers spend a longer period in Namibia that will benefit the wider economy.

- Angling guides should not work in isolation and need to adopt a fresh professional approach working closely with all players in the tourism industry.

Angola

- Private entrepreneurs established two recreational fishing camps in southern Angola. The Flamingo Lodge, situated some 40 km south of Namibe, was established around 1995. In 2000 these entrepreneurs then converted some of the old buildings at Foz de Cunene at the mouth of the Kunene River into accommodation facilities for angling tours. This development expanded their angling area south of Flamingo camp right down to the Namibian border and it includes the Baia Dos Tigres area.

- The same owners also established the Kwanza Tarpon Lodge 100km south of Luanda in October 2005. Rio Longa Lodge was also opened in about 2000 at the mouth of the Longa River about 60km south of Luanda. Both these northern camps cater for angling for the more sub-tropical marine fish and bronze whalers do not occur there. However, the two southern fishing camps share one bronze whaler stock with Namibia.

- Although Angola borders on Namibia, few Namibian angling guides take groups into Angola from Namibia during the quiet winter months when the bronze whalers are more abundant in Angolan waters. The aftermath of the war, current poor infrastructure and poor communication make Angola a difficult country to travel in although the situation has improved considerably in the last two years. Namibian guides need work permits to operate in Angola and although there are some guides who "accompany" people to Angola it remains an area into which Namibian guides can expand in the future.

- Although a few websites offer angling and/or sightseeing tours in Angola, it will be many years before this magnificent country fully recovers from the effects of the civil war. Should the tourist industry in Angola fully recover, specifically in southern Angola, angling tours to Angola will be a valuable income earner both for Angola and for Namibian tour guides. Guides operating in Angola presently are doing so without valid Angolan work permits and Angolan insurances. Few Namibian guides interviewed voiced any wish to work in Angola, despite being paid in US dollars, citing the difficult conditions and the poor infrastructure as the main reasons.

6. Genetics & Stock Assessment

6.1 Genetics

To verify tag-recapture data and to delimit populations it was initially planned that the genetic analysis will be done at a suitable institution with a genetics capability. Many different genetic markers are available for the study of genetic differentiation within and between populations of living marine resources. While the project had sought to use genetic techniques as part of the population structure analysis, this was not achieved as explained below. While this does detract from the depth of understanding of the populations dynamics that was originally sought, the tagging data has nevertheless produced the key outcomes necessary to demonstrate the unequivocal transboundary dynamics of the species.

A relationship was established with Dr. Ken Collins of the National Oceanography Centre, Southampton (NOCS) in the UK. Dr Ken Collins is a marine scientist working at the with interests in artificial reefs and south coast marine habitats and species. (web site: http://www.soc.soton.ac.uk/soes/research/groups/reef). NOCS have the molecular genetics capability to determine the degree of separation, if any, of the South African populations and the Namibia/Angola population. The NOCS is a purpose-built, joint venture between the University of Southampton and the Natural Environment Research Council (NERC). Dr. Collins had sought funding for this as co-funding for the project and was assured of funding from the WWF but ultimately this funding was not forthcoming and the analysis could not be performed.

In addition to this, Prof. Paulette Bloomer of the Genetics Department of the University of Pretoria was the PI of Project LMR/CF/03/04 that reviewed the potential application of genetic techniques for the identification of trans-boundary fish populations in the BCLME region (2003). From the literature consulted, interviews with fisheries scientists and responses from local and international geneticists, it was clear that genetic analyses can make a contribution towards the identification of transboundary fish populations in the BCLME region.

Future genetic work should, however, be carefully prioritised and planned. Planning is especially important because adequate sampling is crucial for obtaining conclusive results. It is also important that fisheries scientists, managers and geneticists work

towards the same goal; i.e. understanding and identifying stocks using only one working definition of a stock.

Her literature research revealed that for bronze whalers Keeney & Heist (2003) found 16 loci for *Carcharhinus limbatus*, dinucleotide repeats, 9 loci amplified for *C. brachyurus* of which 5 appeared polymorphic. Other appropriate loci include ones developed in the lemon shark (*Negaprion brevirostris*), the great white (*Carcharodon carcharias*) and the sandbar shark (*C. plumbeus*). Her task then was to determine if bronze whalers represent one, two or three separate stocks based on mtDNA and microsatellite markers?

In August 2002 fifty genetic samples were collected within 4 days at Bosluisbaai in northern Namibia and in August 2003 a further fifty genetic samples were taken in two days at Baia dos Tigres in southern Angola. Another 35 genetic samples were collected at Sandwich Harbour between January and April 2004. All these samples were stored in pure ethanol. As it would be to risky and expensive to visit angling competitions in South Africa in the hope of collecting genetic samples, colleagues at the Kwazulu Natal Shark's Board for samples from the East Coast. Unfortunately they only had genetic samples from 7 juveniles collected over a long period of time.

Prof. Bloomer was contacted again in the beginning of 2007 to see if she could work-up these samples. After long consultations she deemed it not worthwhile to work with these samples as they were not collected over the same period of time and also not spread evenly over the whole region, specifically from South Africa.

It was thus decided in February 2007, in consultation with the director of BENEFIT, to omit this aspect from the project.

6.2 Stock Assessment

Harvesting of bronze whalers has occurred on a commercial basis in the past (and may do sporadically still). It was thus one goal of the project to investigate the possibility of recommending a sustainable yield in the form of an MSY. This proved impossible due to a paucity of the appropriate data as explained below.

Stock assessment and population modelling of sharks are difficult at best mainly because of the complex sexual and life-stage segregation patterns of populations of various species. However, there is considerable variation among shark species in

their life history parameters and therefore in their productivity and robustness to fishing pressure. Most of the theoretical stock assessment models are based on bony fishes with life histories that are quite different from sharks. Consequently, attempts at shark stock assessment have been few and the results have been questionable or severely flawed. In recent years, demographic analysis has been used to analyze the effects of fishing upon shark populations. Only a handful of species have been analyzed (e.g., Cortés 1995, Sminkey and Musick 1995).

At Baia dos Tigres in southern Angola one pelagic longliner started to harvest bronze whalers in July 2001 and allegedly landed about 80 tons of meat and fins per month in Walvis Bay harbour (Namibia). However, these landings could not be verified. At the time any shark species landed was noted as “shark” or “others”. In August two more longliners joined the harvesting at Baia dos Tigres and by the end of September two Spanish freezer boats also joined. In October two more Walvis Bay registered boats were apparently also preparing to depart for Baia dos Tigres to catch bronze whalers.

Initially it was planned to use stock assessment modelling results to calculate the MSY of the population and from that to estimate the proportion of the population that Angola could harvest annually on a sustainable basis. Such data is crucial for formulating any management plan for a species and it its absence. Unfortunately, no species-specific catch data, effort data (CPUE) or samples were available to for this fishery. This fishery at Baia dos Tigres terminated by the middle of 2002 as the vessels apparently moved northwards looking for other shark species to catch. No bronze whalers catch data could be located in Angola for the duration of the project and hence no stock assessment modelling could be attempted as was planned with the inception of this project.

The formulation of a joint management plan between the two countries for the bronze whaler resource was the ultimate objective of the project. However, for the above reasons the population could not theoretically be assessed and as a result no quantified management plan could be formulated. Nevertheless, several actions should be taken as precautionary measures. These are specified below.

7. Management Considerations

7.1 Background

Sharks have been around for about 400 million years and for the last 160 million years did not have to adapt to any specific changing circumstances. They have very few natural enemies, except their own kind, they live long, grow slow and have a low reproduction rate. Large pelagic sharks roamed the oceans freely until civilised man established political borders, EEZ's, the high seas areas, various protocols and treaties. Accordingly large pelagic highly migratory species such as tunas and billfishes were classified as trans-boundary species and only in the last 50 years have international bodies such as ICCAT and CCAMLR managed them. Amazingly, it is only in the last decade that ICCAT added large pelagic sharks as trans-boundary species to their list of controlled species and started to urge member countries to submit annual shark catches to the Commission. Member countries were also urged to develop their own National Plans of Action (NPOA) for the Management of their sharks based on the International Plan of Action (IPOA) for sharks of the FAO (although this is not mandatory).

Except for some artisanal shark fisheries, mostly in Asia and around the African continent, sharks were historically mostly caught as bycatch in many of the commercial fisheries. Sharks were not directly targeted since the meat was not considered palatable and being of low commercial value. However, as the commercial bony fish and finfish stocks became overexploited in the 1980's the demand for shark meat rose dramatically in Asia and also in Australia. The resultant increase in shark catches has largely been the result of ever-increasing prices paid for shark products in Asia and the ease with which some of these products (e.g. dried shark fins) can be processed and transported for exportation.

In Asia sharkfin soup has been a delicacy throughout history but was only affordable by the rich. As the economies of Asian countries grew, more people could afford this commodity and the demand for shark fins has therefore risen astronomically over the last decade. Because of its large size, bronze whalers are very desirable for the Asian shark fin market. Juveniles are targeted for their flesh because its mercury content is lower than that of the larger sharks. This could lead to severe pressure on shark stocks, particularly if both adults and juveniles are exploited.

The pelagic shark fisheries boomed and mostly “busted’ globally, and only a handful fisheries, such as the school and gummy shark fisheries of Australia, have been reasonably sustainable over the last 70 years only due to ever more stringent management measures being imposed as the stocks became close to being overexploited. These fisheries started off close to shore using hand lines but as the sharks were becoming smaller and scarcer the fishermen continuously had to move further offshore and into deeper waters and they also had to change to different fishing gears such as entangle nets.

In the last decade or so many treaties and protocols have been ratified and signed by countries in southern Africa. Of importance for the management of trans-boundary species such as pelagic sharks are the following;

7.2 SADC Protocol on Fisheries

The SADC (Southern African Development Community) Protocol on Fisheries was signed on 2 September 2001 by all the member states which included Angola, Namibia and South Africa. According to the principles of Article 4, the responsibility for the implementation of the Protocol is primarily national, but in the case of shared resources, State Parties shall co-operate with one another to ensure that the objective of this Protocol is achieved.

The protocol further states “State Parties shall take appropriate measures to regulate the use of living aquatic resources and protect the resources against over-exploitation, whilst creating an enabling environment and building capacity for the sustainable utilisation of the resources”.

Finally “State Parties with capacity in matters of fisheries shall endeavour to transfer skills and technologies to other State Parties to enhance effective regional co-operation”. This protocol effectively forces member states such as Namibia and Angola that has shared resources to manage such resources jointly on a sustainable basis.

7.3 Marine Resources Acts and Regulations

Namibia

Before 2000, the only shark that enjoyed protection in Namibian waters was the great white shark *Carcharodon carcharias*, However, Namibia amended its Marine Resources Regulations in December 2000 (Anon, 2001) and placed a restriction of only one shark per angler per day that may be retained. The bronze whaler is one the four shark species implicated here. Previously there was no limit on the number of sharks that may have been retained per day. It is recommended that legislation be formulated to prevent any possible future commercial harvesting of bronze whalers in Namibian waters.

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 (Peterson et al., 2007). 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. The Act illustrates an attempt to harmonise various separate pieces of legislation governing Angola's marine resources. It is recommended that legislation be formulated to prevent any possible future commercial harvesting of bronze whalers in Angolan waters.

7.4 NPOA-sharks

Namibia

In March 2003 Namibia's National Plan of Action for the management of sharks was finalised and implemented (Holtzhausen, 2003). Bronze whalers are included in this document as a trans-boundary species that should be jointly assessed and managed sustainably by the governments involved. Namibia is a full member of ICCAT.

Angola

This country is in the process of developing its own NPOA-sharks and is also a full member of ICCAT. Bronze whalers should be included in the NPOA as a trans-boundary species to be jointly assessed, and sustainably managed by both countries.

7.5 Marine Protected Areas (MPAs)

Namibia

Currently no MPA's exist in Namibia. This imbalance is soon to be addressed through the NACOMA (Namibian Coast Conservation and Management) project). Namibia is in the process of declaring MPAs around all its offshore islands which are all situated in the southern area (Anon, 2007). It also includes an inshore buffer zone from Meob Bay southwards to the Chamais Bay stretching from the high-water mark to six nautical miles offshore. It is hoped that this will include all possible pupping areas of bronze whalers that occur there.

Angola

Results from this project showed that Baia Dos Tigres is a breeding, and a possible nursery area for bronze whalers. It is therefore recommended that this area be declared a MPA by the Angolan Government. Anecdotal evidence suggests that this area used to be a MPA or a specially protected area before the outbreak of civil war in Angola but no concrete evidence of this could be found. It is further recommended that no gillnetting be allowed as juvenile bronze whalers occur between Baia dos Tigres and Namibe. They could be easily caught with these nets in shallow waters.

7.6 Recommendations from BCLME Trans-boundary Diagnostic Analysis

The main aim of this project was to formulate a joint management plan for the bronze whaler resource shared by the Namibia and Angola. However, this could not be achieved and a diagnostic analysis was performed to evaluate the project.

A Transboundary Diagnositic Analyis was developed by the UNDP (United Nations Development Programme) in Windhoek, October 1999. It is a regional commitment to the integrated management, sustainable development and protection of the BCLME by Angola, Namibia and South Africa. Accordingly, for this project a synthesis matrix for a trans-boundary diagnostic analysis for bronze whaler sharks was used to

evaluate the project according to 1) the perceived major problem, 2) the main root cause and 3) areas where action is proposed.

Table 3. Trans-boundary diagnostic analysis for bronze whaler sharks.

Perceived Major Problem	**Main Root cause**	**Areas where action is proposed (this project)**
1. Decline in shark stocks	Difficulty in monitoring & understanding, lack of awareness	Sustainable management of the resource – assessment & economic study
2. Habitat destruction & altercation	Inshore trawling in breeding & pupping areas	Protection of vulnerable species & habitats - MPA's
3. Loss of biotic integrity	Uncontrolled harvesting will deplete the gene pool forever	Conservation of biodiversity - joint management plan
4. Inadequate capacity to assess resource	Lack of training & funding	Capacity strengthening & training – Angola specific

7.7 Major Conclusions and recommendations

1. The paucity of any catch data for bronze whalers harvested in Angola prevented the use of a theoretical fishery model to assess the resource as such. Therefore, it is not possible to say in what state the resource is currently. According to anecdotal evidence from some Namibian angling guides, bronze whaler numbers and sizes caught in Namibian waters for the last two years were normal. There is currently no commercial harvesting of bronze whalers in Angolan waters and this together with Angola currently formulating its own NPOA-sharks bodes well for the resource. A socio-economic assessment of the bronze whaler sport fishery in Namibia clearly shows that this is a very valuable contributor to the Namibian economy. No response was received on the socio-economic questionnaire send to Angolan fishing guides.

2. From this project it is thought that the pupping area is close offshore in central Namibia (Area 1). No trawling takes place here. Namibia is furthermore in the process of declaring some MPA's in the south (south of Meob Bay) which should offer protection to vulnerable species and habitats in this area. More MPA's are planned for central Namibia. The breeding, nursery and juvenile areas from Baia dos Tigres to Namibe, should be protected from inshore trawling to prevent habitat destruction and altercation and to offer protection to vulnerable species such as juvenule bronze whalers.

3. Uncontrolled harvesting of bronze whalers in Angola seems to have stopped in 2003. In Namibia bronze whalers are not harvested commercially. Namibia and Angola are both working towards an Ecosystem Approach to Fisheries (EAF) and are moving away from single species management. This approach is especially suited to trans-boundary species such as large pelagics as it takes the whole ecosystem into account including trophic interactions and environmental processes.

4. For assessing the bronze whaler resource, a time series of species-specific catch and effort data is necessary. Therefore, if this species is to be harvested in Angola in the future, such data should be collected wherever possible. Namibia has only one biologist working on pelagic and demersal sharks only part-time as he also runs the Large Pelagic section. Angola is in a similar situation. Also in both countries no stock assessment of pelagic sharks have been undertaken yet as sharks, until very recently, were not important commercial species. This situation is changing and in future shark specialists should be appointed or regionally trained.

It is recommended that the Benguela Current Commission:

5. Ensures that continuation of efforts in the region to jointly manage this important and valuable trans-boundary resource is pursued. Research on and monitoring of the bronze whaler resource should continue in the BCLME region.

6. establishes of a Joint Working Group under the Ecosystem Coordinating Committee of the BCC

7. From the above two points It is strongly recommended that the tagging effort be continued to gather more data on seasonal movements between Namibia and Angola. To verify tag-recapture results and delimit populations it is further recommended that the genetic research be continued.

8. The dynamic sport-angling fishery for bronze whalers in Namibia earns the country at least N$8 million annually (without travelling costs) and this figure could easily more than triple through careful expansion of the industry. It is recommended that Namibian angling guides form an association to protect

this valuable industry. It is further recommended that angling tour operators in southern Angola should concentrate on marketing bronze whaler angling tours.

9. Although there is currently no commercial harvesting of bronze whalers in Angola, it is strongly recommended that Angola consider promoting the non-consumptive utilisation of bronze whalers in its waters instead of harvesting them commercially. There is no doubt that southern Angola will become a huge angling tourist attraction as the country's infrastructure develops towards its full potential. This would by far outweigh the short-term financial gain that can be derived from commercial harvesting of this resource.

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Appendix 1 - Images

Picture 1. The poor man's marlin – a bronze whaler landed from the shore at Bosluisbaai, northern Namibia.

Picture 2. A Pop-up Satellite Archival Tag (PSAT) attached to the dorsal fin of a bronze whaler with a harness. Note conventional yellow dart tag too.

Appendix 2: Terms of reference for project

Terms of Reference for: BCLME Project LMR/CF/03/16

Development of a Management Plan for Bronze Whaler Shark Resources in the BCLME Region

Background:

Benguela Current Large Marine Ecosystem (BCLME Programme is a multi-sectoral regional initiative by Angola, Namibia and South Africa whose objective is to facilitate the integrated management, sustainable development and protection of this unique eastern boundary upwelling ecosystem. It is funded by the Global Environmental Facility (GEF) under its International Water portfolio and is implemented by the United Nations Development Programme (UNDP) with the United Nations Office for Project Services (UNOPS) as executing agency. The three member countries provide further financial and in-kind contributions.

In South Africa, bronze whalers are targeted by sport anglers, and harvested by recreational anglers for their meat and fins. In Namibia this species supports a growing sport fishing industry where most of them are tagged and released. In Angola this species is harvested for their meat and fins. It is hypothesised that one population inhabits the BCLME area & therefore co-management for sustainable use of this resource is imperative.

Objectives:

The specific objective of project LMR/CF/03/16 is to conduct a study of bronze whaler resources to determine its distribution, abundance and population structure in order to ensure sustainable management of the resources in the region.

Scope of Project LMR/CF/03/16:

BENEFIT will be expected *inter alia* to undertake the following:
Design and execute study to determine population structure, abundance and distribution of bronze whaler resources in the BCLME region
Expand the existing trans-boundary tag and release programme between Angola and Namibia to incorporate the existing South African based tagging database
Incorporate the existing South African based tagging database.
Deploy satellite tags in each country

Outputs Required:

Comprehensive report including the following:
The status (distribution, abundance, population structure) of the bronze whaler resource in the region
A draft joint management plan, including implementation strategies for consideration by the governments of the three countries

Timetable:

The project is scheduled to start in 1 August 2003 and completed not later than July 2006. Deliverables include:

Status of bronze whaler resources by December 2005
Draft joint management plan by May 2006
Progress reports after every six months

Training and Capacity Building:

Capacity building and training is a high priority in the BCLME Programme. Potential Contractors tendering for this project should indicate how capacity building and training will be addressed. In particular the contractor will be expected to:

Interact with coastal communities and tour operators in terms of training in data collection
Provide training to relevant staff of IIM. NatMIRC and MCM in tag and release procedures and analysis of data
Involve tertiary education institutions (It is envisaged that aspects of the work could lead to post graduate qualification)

Criteria for Participation:

Where ever possible BENEFIT will be expected to include nationals or permanent residents of BCLME countries in the team.

Additional Requirements:

Close co-operation with relevant research institutes (IIM, NatMIRC and MCM) and angling tour operators essential
Linkage with activities of the Socio-Economic Task Group of BCLME
Relationship with Tourism Boards, Angling Clubs, individual anglers
Linkage with BCLME Non Consumptive Project (LMR/NC/03/01)
The contractor should be familiar with the potential impacts of the environment on the resources and, where possible, link with activities of the BCLME Environmental Advisory Group.

Appendix 3: Lessons Learned

Introduction

As with other BCLME projects formulated in 2002/03, some were very ambitiously designed such as this project as there was a need to address, as a matter of urgency, the uncontrolled harvesting of bronze whalers in southern Angola. As described elsewhere the main objectives of the project was to 1) show that Namibia and Angola share one bronze whaler population with a separate population occurring in South Africa through tag-recapture and 2) to formulate a joint management plan between Namibia and Angola.

Deliverables

The first objective was achieved except for the genetic study that could not be completed for reasons described in Chapter 6. The second and ultimate objective could not be achieved as the Namibian/Angolan bronze whaler population could not be assessed using a fishery model due to the absence of catch and effort data for reasons described in chapter 6.

Terms Of Reference

In the TOR for the project (in Appendix 2) the title given was “Development of a Management Plan for Bronze Whaler Shark Resources in the BCLME Region. The original thrust of the project was to assess the shared resource between Namibia and Angola, culminating in a sustainable management plan and not for the whole region as it was hypothesised that South Africa has a separate population. Nowhere was their any plans or budgeted to visit or work in South Africa except for obtaining genetic samples from there. Therefore, the working title of “The Migratory Behaviour and Assessment of the Bronze Whaler (*Carcharhinus brachyurus*)” was used throughout the project.

Similarly Appendix A of the TOR states that “it is hypothesised that one population inhabits the BCLME area etc.” which was never stated. Also it was never the intention to deploy satellite tags in South Africa nor was it intended to train MCM staff in ”tag-and-release procedures and analysis of data”.

Overland Field surveys

Many field trips were planned and budgeted for into southern and central Angola, either overland by vehicle or flying in. However, logistically it was very difficult to move around in a country whose infrastructure, specifically roads, was all but destroyed by the civil war. For example, in the south of the country all roads were in very bad condition and it took a full two days to travel the 400 km from either the Santa Clara or Ruacana border posts just to reach Lubango. It then took another half a day to travel 160 km of a badly potholed road to reach the coastal town of Namibe. Similarly, it also took two full days of travelling from the Ruacana border post along the Cunene River through the Iona National Park to reach Foz de Cunene near the river mouth. Thus, it took a full three days of travelling from Swakopmund to reach the southern Angolan coastline and of course, another three full days back to Swakopmund. Thus, six days per field trip was spent just travelling to and from the coast. Actual survey days, which included more driving, added to at least another five

days per survey which proved to be too long. In addition, private vehicles were used from Namibia on these rough roads which sometimes damaged the vehicles.

It was envisaged for the PI to fly into Angola, meet up with the co-investigator, and drive to various places. This did not work either as very little equipment (20 kg) could be taken on a plane. Then a 4x4 vehicle had to be hired at an exorbitant daily rate. To catch bronze whalers from the shore expertise and angling experience are needed and therefore expert shark anglers from Namibia were used as none are available in Angola. However, flying them into Angola was not feasible and overland field surveys proved to be too long and arduous.

Budget

Similarly, budgets had to be worked out hastily and sometimes overestimated because of the high currency exchange rate at the time. As stated before, many field trips were not done and the money budgeted for that was not used. Some examples are:

Training – stipend for M.S. for the co-investigator. An amount of N$80 000 was budgeted for him to use the project data for a masters degree. However, he has not yet attained his basic degree by September 2007.

N$26 000 was budgeted for to rebuild the four satellite tags if they were found again but only one was found and rebuilt.

N$170 000 that was budgeted for flights in Angola was not used for reasons stated elsewhere.

Because fewer field trips were done as was planned an amount of N$62 000 for equipment (bait, tags, fishing tackle etc.) was not used for reasons stated elsewhere.

N$15 750 for a consultant to do the stock assessment but which could not be done for reasons stated elsewhere.

This alone comes to a total of N$353 750 that was not used.

Appendix 4: Outputs of project: publicity, presentations and publications

- On 7 March 2003 the Namibian National Plan for the Management of sharks (NPOA-sharks), written by the PI, was implemented. This management plan has a direct bearing on this project as it includes management recommendations for trans-boundary species such as the bronze whaler.

Various popular articles on this project were published.

- A popular article on the August 2002 Eco Challenge in the Skeleton Coast Park (South African 4x4 Magazine, September 2002 – Volume 10, No 9.).
- A popular article on the August 2003 Eco Challenge in southern Angola (Explore Mitsubishi owners magazine – Spring 2003, September 2003).
- A popular article on the August 2003 Eco Challenge in southern Angola (South African 4x4 Magazine, Volume 11, No 9).
- A popular article on the 2003 August 2003 Eco Challenge in southern Angola. "Inside Angola on the 4x4 Eco Challenge".16-20.
- An article on this project in the BCLME.current news. Issue 2 – July 2004.
- Another article on this project in Bay News of the Walvis Bay Municipality, 2004.
- Various articles in local newspapers (Namib Time, Republikein & Allgemeine Zeitung etc.)

Various TV documentaries were produced covering the project.

- A 4-part SABC-TV documentary on the August 2002 Eco Challenge in the Skeleton Coast Park. Also broadcasted on DSTV.
- Included in a 4-part SABC-TV documentary on the August 2003 Eco Challenge in southern Angola. Also broadcasted on DSTV.
- A 20-minute SABC-TV documentary covering the tagging survey during which the satellite tags were fitted in Namibia was broadcasted in September 2004. "The Bronzies of Namibia – 'n Programme for 50/50. 2004. This was well received by the public.
- Bronze whaler tagging in Namibia formed Part of the BBC series "Animal Planet" shown worldwide in 2006.

Talks, Papers & Poster Presentations

- Elasmobranch Symposium, Santiago de Compostela, Spain. September 2002. Poster presentation. Title: Trans-boundary Bronze Whaler (*Carcharhinus brachyurus*) Tagging Program between Namibia and Angola.

- BENEFIT Forum, Swakopmund, Namibia. April 2003. Project Proposal: Migratory Behaviour and Assessment of the Bronze Whaler (*Carcharhinus brachyurus*).

- BENEFIT Forum, Swakopmund, Namibia. April 2004. Presentation: Migratory Behaviour and Assessment of the Bronze Whaler (*Carcharhinus brachyurus*).

- South African Marine Science Symposium, Durban, South Africa. July 2005. Poster Presentation. Migratory Behaviour and Assessment of the Bronze Whaler (*Carcharhinus brachyurus*).

- BENEFIT Forum, Swakopmund, Namibia. April 2006. Presentation: Migratory Behaviour and Assessment of the Bronze Whaler (*Carcharhinus brachyurus*).

- Annual Research Meeting, Swakopmund, July Namibia. 2006. Presentation: Migratory Behaviour and Assessment of the Bronze Whaler (*Carcharhinus brachyurus*).

- BCLME Workshop, Windhoek, Namibia. End January 2007. Presentation: Migratory Behaviour and Assessment of the Bronze Whaler (*Carcharhinus brachyurus*).

Appendix 5: Capacity building

- In December 2002 the co-investigator was flown to Namibia from where he participated in the first survey to southern Angola while he was trained in shark tagging, shark research and survey methods.
- The co-investigator participated in the August 2003 survey again in southern Angola.
- In October 2004 the co-investigator participated in the Orange-Kunene Rivers estuary project where he and the PI tagged bronze whalers for this project. All participants from Angola were introduced to shark tagging procedures.
- In March 2005 the co-investigator participated in another overland bronze whaler tagging survey to southern Angola with the PI
- Unfortunately the co-investigator still has not attained his first degree (currently studying at UNAM, September 2007) and therefore the data generated by this project could not be used by him for a M.Sc. as originally planned.

As the PI for the project, to me the biggest achievement was to bring the vulnerability and man-made dangers to the attention of the inhabitants of the BCLME region, the inhabitants of the SADC countries and also to millions of viewers from around the world especially the United Kingdom.