Namibia Nature Foundation

British Ecological Society

Nedbank Namibia
Go Green Fund

The Namibian Dolphin Project

Ecology and conservation of coastal dolphins in Namibia

20 Nov 2009 – 25 pages & 1 appendix

This report should be referred to as: Elwen, SH and RH Leeney (2009). Report of the Namibian Dolphin Project 2010: Ecology and Conservation of Dolphins in Namibia - Submitted to the Ministry of Fisheries and Marine Resources, Namibia

Table of Contents

Research Team

Principal Investigator: Simon Elwen PhD
simon.elwen@gmail.com (+27) 071 139 5951 SA and (+264) 81 420 4968 Nam
Postdoctoral Fellow, Mammal Research Institute, University of Pretoria.
Affiliated with the *Namibia Nature Foundation* for the duration of this project.

Principal Investigator: Ruth Leeney PhD
ruleeney@yahoo.co.uk
Provincetown Centre for Coastal Studies, Mass, USA
Affiliated with the *Namibia Nature Foundation* for the duration of this project.

Students: Mr Theodore Meyer – University of Pretoria, Honours student (4^{th} Year)
Project title: Managing human-dolphin conflict through the investigation of critical habitats of bottlenose dolphins.

Collaborators:

Mr Johannes Iitembu & Mr Sion Iikela – MFMR NATMIRC

Ms Heidi Skrypzeck – MFMR NATMIRC (summer season only)

Ms Tess Gridley & Dr Vincent Janik – University of St Andrews, acoustic recording of bottlenose dolphins

Dr Ben Wilson & Dr Kenny Black – Scottish Association for Marine Science, fatty acid and isotope study of dolphin population structure and diet.

Dr Victoria Tornero, Ms Keshni Gopal and Dr Leszek Karzmasrki – University of Pretoria, analyis of genetic population structure (KG) and heavy metal pollutants in Heaviside's dolphins (VT)

Dr Nick Tregenza – Chelonia Ltd, Static acoustic monitoring of dolphins using C-PODs

Dr David Carslake **–** University of Warwick**,** Static acoustic monitoring of dolphins using C-PODs

Advisory Panel (informal):

Mr Rod Braby – NACOMA

Dr Chris Brown – NNF

Mr Naude Dreyer – Sandwich Harbour tours

Mr John Paterson – CETN

Dr Jean Paul Roux – MFMR Lüderitz

Mr Walther Schäfer– Chairman MTAN (and Mola Mola tours)

Abbreviations used:

MFMR – Namibian Ministry of Fisheries and Marine Resources

MET – Namibian Ministry of Environment and Tourism

NNF – Namibia Nature Foundation

CETN – Coastal Environment Trust of Namibia

MTAN – Marine Tour Association of Namibia

SAM – Static Acoustic Monitoring

Executive Summary

This report summarises the research and preliminary analyses of the Namibian Dolphin project to date. Data on the distribution, habitat use, and abundance of bottlenose and Heaviside's dolphins have now been collected from three seasons, 2008 winter (the pilot study), 2009 summer and 2009 winter. Data have been collected in Walvis Bay (primary site) and Lüderitz.

The coastal delphinids of Namibia have been poorly studied to date and little data exist on the movements, abundance and general ecological relationships of Heaviside's, dusky and bottlenose dolphins in Namibian waters. Of immediate conservation concern is coastal development and port expansion in Walvis Bay, the large marine ecotourism industry in the Walvis Bay area and the potential effects of a growing mariculture industry.

Visual habitat surveys in Walvis Bay confirmed that Heaviside's dolphins use significantly deeper water than bottlenose dolphins and are considerably more abundant in the ~1nm^2 of water directly north of Pelican Point than anywhere else in the study area. Heaviside’s dolphins were almost never sighted within the bay although sightings away from the Pelican Point area were more common in summer than winter months. Bottlenose dolphins were most frequently sighted within the protected waters of the bay (where they overlap considerably with oyster farms) and close to shore along the coast to the north and south of the bay. Their distribution varied considerably between seasons, with the majority of sightings within the bay occurring around the oyster farms in the summer months (48%), but away from the oyster farms in the winter months (30% and 17% in 2008 and 2009). Bottlenose dolphins used the reef area north of Bird Island in all seasons, with the predominant behaviour observed here being ‘resting’, suggesting that this is an important refuge site for this population.

Abundance estimates from the 2008 pilot study were fully checked and reanalysed. These numbers should be regarded as an estimate of the number of dolphins using the bay during the study period (June – July 2008). The bottlenose dolphin population was estimated as 77 (95%CI: 71 – 122) and the Heaviside's dolphin population as 505 (95%CI: 335-764). Preliminary analysis of photo-ID images from 2009, confirm multiple identifications of individually recognisable bottlenose dolphins between seasons and several identifications of Heaviside's dolphins, thereby confirming site fidelity of these animals to the area.

Human-dolphin conflict: up to 25 tour boats operate in Walvis Bay simultaneously: 21 ski boats and 4 catamaran sailing vessels. The maximum number of vessels seen from the research vessel at a one time within the same general area (opportunistic observations) was 12 within ~1nm^2 at Pelican Point; around cetaceans, the largest number of vessels observed was 10 (during a sighting of 2 killer whales in 2008). The high number of tour boats in Walvis Bay is of serious concern, as studies in other areas have shown negative effects of boat-based tourism on cetaceans. Although some dolphins were seen to pass between the lines of the oyster farms, the farms take up considerable space in an area where bottlenose dolphins were regularly seen to surface feed. The environmental effects of the faecal output of such a high concentration of oysters are unknown and more work is needed prior to any expansion of the farms.

The NDP pioneered the use of static acoustic monitoring on Heaviside’s dolphins during the 2008 pilot study. Results from the pilot study showed the technique to be very powerful in determining dolphin habitat use at fine spatial scales. Preliminary results described an unsuspected diel movement pattern of Heaviside's dolphins at Pelican Point – the animals are apparently more active in this area at night than during the day, but use the region during all hours of the day. During 2009, 5 hydrophones (C-PODs) have been acquired and deployed during the month of August in Walvis Bay and Lüderitz. Data are not yet available from these instruments as their first download is only scheduled for December.

Skin biopsies were collected from 3 humpback whales, 1 southern right whale, 1 bottlenose dolphin and 34 Heaviside’s dolphins (half each in LDZ and WB). Samples have been split and will be used for multiple analyses: 1) Variation in stable isotopes of $\delta^{13}C$ & $\delta^{15}N$, 2) Fatty acid analysis, 3) Variation in stable isotopes of δ^{12}Sulphur 5) genetic population structure 6) heavy metal pollution levels.

The NDP has received a grant from the Walvis Bay Municipality to develop and equip a locally based strandings response team. A workshop was held on the 31s August 2009 to identify potential core members of the group, set up communication lines and protocols. Further, NDP staff attended 2 stranding events of a humpback whale and 19 bottlenose dolphins, see text for details.

Project Background, Goals and Outputs:

General background:

Namibia is the second least densely populated country in sub-Saharan Africa and the vast majority of its ~1500km of coastline is very sparsely populated. Namibia has a politically complicated history and marine research has been strongly directed towards areas of immediate economic importance such as fisheries. Consequently, marine mammal research has been primarily focussed on those species having a perceived or direct impact on commercial fisheries, particularly the Cape fur seal *Arctocephalus pusillis.* Very little data exist on the local ecology of delphinids, despite potentially significant human threats in the marine environment, including bycatch in fisheries, pollution, prey depletion by fisheries and a rapidly growing wildlife-focused tourism industry.

Namibia currently does not have a legal framework governing the interaction of humans and cetaceans with respect to hunting, formal tourism, non-commercial viewing, stranded animals etc. Growing concern over the potential impact of the marine tourism industry resulted in the development of the Marine Tourism Association Namibia (MTAN) and, driven by the Coastal Environment Trust of Namibia, the development of an internal “Code of Conduct” (CoC) detailing acceptable behaviour around whales and dolphins. MTAN consists primarily of owners and skippers of marine tour boats who operate in Walvis Bay. However, the CoC is not an enforceable, legally binding document and infringements are frequent. For the Code of Conduct to be upgraded to a legal status as has been done in South Africa and many other countries, it will need to be based on a precautionary approach and as far as possible, sound scientific data on the ecology and conservation status of cetaceans in Namibian waters. For these reasons, the Namibian Dolphin Project has received strong support from local NGOs (NNF, CETN, NACOMA) and the Namibian Ministry for Fisheries and Marine Resources. Their support for this independently run project has been strong and invaluable to its success.

Scientific background:

The collection of baseline data on cetacean abundance, distribution and habitat use in Namibian waters is essential to the evaluation of the conservation status of these populations as well as their role in the ecosystem. Up to 25 species of cetacean are known from Namibian waters (http://www.nacoma.org.na/), primarily from stranded specimens. Several species of odontocete can be regularly seen in Namibian waters including the Heaviside's, bottlenose, dusky and southern right whale dolphins. Of chief conservation concern are Heaviside’s and bottlenose dolphins which are the most coastal of Namibia’s dolphins. Both these species are potentially impacted by coastal development and aquaculture and are currently the focus of intense marine tourism activities in the Walvis Bay area.

Heaviside's dolphin *(Cephalorhynchus heavisidii*) is a poorly studied species; it has a limited range and is endemic to the Benguela ecosystem. Recent research in South Africa (Elwen et al. 2006, Elwen 2008) has shown individuals to have small home ranges only tens of km alongshore and the population to have a close ecological link, in terms of their movement patterns and distribution, with their predominant prey shallow water hake (*Merluccius capensis*). A single season estimate from the Namibian Dolphin project pilot study in winter 2008 (Elwen & Leeney 2008) estimated the number of Heaviside’s dolphins using the Walvis Bay area to be between 335 and 764 animals.

The bottlenose dolphins found on the west coast of Africa and offshore in the Atlantic are ‘common bottlenose dolphins’ (*Tursiops truncatus*) and are recognised as a separate species to the smaller Indian Ocean bottlenose dolphins (*Tursiops aduncus*) found commonly along the inshore waters of Africa east of Cape Agulhas (Natoli et al. 2004). These dolphins form an isolated inshore population, which ranges between roughly Sandwich Harbour and Cape Cross (Findlay et al. 1992). This population is unique within the Benguela ecosystem, and the nearest other populations of related bottlenose dolphins are found in offshore waters (>300m depth) and north of the Benguela ecosystem (i.e. from central Angola northwards). A single season estimate from the Namibian Dolphin project pilot study in winter 2008 estimated the number of bottlenose dolphins using the Walvis Bay area to be between 71 and 122. The isolation and small size of this population make it vulnerable to any threats in its environment as the population is not likely to be replenished by immigration.

Both bottlenose and Heaviside's dolphins show high site fidelity to small ranges, a factor which is likely to increase individual exposure to any threat due to a higher encounter rate for individual animals. A low dispersal rate in marine mammals has also been associated with the isolation and splitting of sub-populations and lack of recovery in areas of high impact. For example, the Hector's dolphin of New Zealand, which is closely related to the Heaviside's dolphin, has been highly impacted by mortality in inshore gill-nets. The Hector's dolphin is considered highly endangered and is fragmented into several populations between which there is little mixing (Pichler et al. 1998). Understanding the spatial and temporal distribution of animals and the factors affecting these is of central importance to understanding how they use the environment, the degree to which they are exposed to threats and their likely response to changes in the environment.

There is a large body of evidence showing clear behavioural changes in many species of cetacean caused by associated boat traffic, including horizontal avoidance, longer dives, increased speed and changes in vocalization (Bejder et al. 2006, Corkeron 1995, Janik & Thompson1996, Kruse 1991, Van Parijs & Corkeron 2001, Williams et al. 2002). More recently, longer term studies have shown that these short term behavioural changes may accumulate into larger population-scale effects. Relatively low levels of boat based tourism (2 boats) have been related to the permanent movement of some individuals away from impacted areas (Bejder et al. 2006) whilst high levels of boat traffic can reduce the use of key habitat areas (Lusseau 2005). Certain behavioural states (socialising and resting) are more sensitive to harassment than others (Lusseau 2003), but if these sensitive behaviours occur in spatially predictable areas, then it is possible to develop a management plan that allows for controlled use of the area with tour boats avoiding these keys sites, thereby minimizing disturbance to the dolphins (Lusseau & Higham 2004).

The effects of aquaculture on cetaceans are not well studied. Positive interactions may exist as the nutrient shedding and the creation of artificial reefs by farms can lead to increased stocks of wild fish in the immediate vicinity. However, excessive enrichment of the environment can lead to environmental damage including harmful algal blooms and changes in the benthic fauna (Kemper, Gibbs 2001). Further, a positive interaction between dolphins and aquaculture has only been demonstrated in the relatively nutrient poor Mediterranean Sea, where some individuals showed a preference for feeding in the vicinity of the farm, but any potential 'gains' to the population were significantly outweighed by the loss of animals to entanglement in the anti-predator nets (Diaz-Lopez & Bernal-Shirai 2007). The population level impacts of dolphin mortality are dependent on the rate of entanglement and size and health of the impacted population.

Besides direct loss of individuals through entanglement or injury, habitat loss may be one of the largest, but most subtle impacts of aquaculture on nearshore dolphin populations. Observations of dolphins around shell fish farms (which consist of 'open' buoyed lines similar to those used in Walvis Bay for oyster aquaculture) show clear patterns of avoidance and reduced usage of the farm area compared to either adjacent areas or the same area prior to or after farming. Dolphins do not use their home ranges in a uniform manner and may preferentially use certain areas for feeding, socializing, calving and resting (Karczmarski et al.2000aLusseau, Higham2004Watson-Capps, Mann2005). Protected bay areas such as Walvis Bay are often used as calving areas by cetaceans and areas near reefs (such as in the Bird Island vicinity) are frequently abundant with fish life and used for feeding. Loss of these key habitats could have important population level impacts for dolphins by changing the type or reducing the amount of food available. Added to potential effects from pollution and entanglement, fish farms have the potential to seriously impact a localized population of marine mammals.

The collection of baseline data on cetacean abundance, distribution and habitat use in Namibian waters is essential to the evaluation of the conservation status of these populations. The Walvis Bay area was chosen as the site of the initial study as it is the largest area of human coastal habitation in Namibia and is thus where human threats are likely to be highest. The project aimed to collect data on the distribution, movements, habitat use and abundance of Heaviside's and bottlenose dolphins in Walvis Bay. These data will provide information on the conservation status of these populations and are central to the development of a management plan for these species.

Project goals:

- To estimate the abundance of Heaviside's and bottlenose dolphins in the Walvis Bay area using photographic mark-recapture.
- To use static acoustic monitoring techniques to produce novel data on Heaviside's dolphin echolocation behaviour.
- To describe key habitats used by Heaviside's and bottlenose dolphins within the near shore environment, and to investigate the overlap of dolphin habitat use with potential anthropogenic influences in the region such as boat-based tourism, ship traffic and mariculture.
- To combine the results of visual survey data (broad area, small temporal window) and static acoustic monitoring data (multiple small areas, broad temporal window) to investigate variation in habitat use over time.
- To work closely with marine tour operators to investigate their routes, tours and procedures for comparison with dolphin habitat use patterns.
- Collect skin samples from all cetacean species for analysis of genetic variation and population structure.
- Collection of skin and blubber samples from focal dolphin species for analysis of populations structure (stable isotopes, genetics), diet (fatty acids) and heavy metal contaminant load.
- To communicate, interact and work closely with the current networks of tour operators (MTAN), government (MFMR, MET) and conservation organizations (NNF, CETN) to share knowledge, skills and information.
- To investigate the data available from existing cetacean strandings and collate and analyse this data. To encourage more dedicated collection of data and material from stranded animals through the training and education of interested and involved parties (e.g. coastal tour guides, government rangers). To aid local authorities in developing and refining the existing strandings reporting network including a central data repository.

Study area

The Benguela ecosystem is a typical cool eastern boundary current which flows northward along the coast of southwestern Africa, from the Cape of Good Hope to southern Angola and represents one of the most productive ocean areas in the world (Brown et al. 1991). The high productivity of the ecosystem is a result of wind driven upwelling which results in localised and predictable upwelling cells of high productivity, that in turn affect lower trophic levels over a limited spatial range and separate the northern and southern halves of the system with implications for prey species and densities alongshore. The continental shelf off southwestern Africa is relatively deep and broad, ranging from 20-40 nm from the coast (maximum 90 nm). The coastline is very exposed being generally straight with few bays and it is dry, with few rivers.

Walvis Bay is a large (~10x10km) shallow (max ~30m) bay protected from the open ocean by a long sand spit ending at Pelican Point (Fig. 1). The predominant weather conditions in the area in winter are south-westerly swells and south-westerly winds which tend to blow most strongly in the afternoons. As such the bay provides considerably protection from the elements and glassy flat sea conditions in the mornings are not uncommon. The direction of the prevailing swell and wind is causing the sand spit ending at Pelican Point to continue growing at roughly 100m per year. Currents in the bay tend to be clockwise driven by swells entering the bay from the NW and winds blowing from the southerly quarter. There tends to be a confluence of waters and currents at Pelican Point resulting in a visible current line and often considerable differences in the water clarity either side of the point.

The town of Walvis Bay (population ~55 000) situated at the south-eastern edge of the bay hosts the largest commercial harbour in Namibia. At the south of the bay a shallow ‘inner-lagoon’ extends a further 8km southwards. The majority of the inner lagoon is <3m at high tide and large portions dry at low tide. Although the bottlenose dolphins are known to enter the inner lagoon, they do so considerably less frequently that they used to (reports from local tour operators and conservationists). This may be due to the increasing shallowness of the lagoon resulting from siltation in recent years.

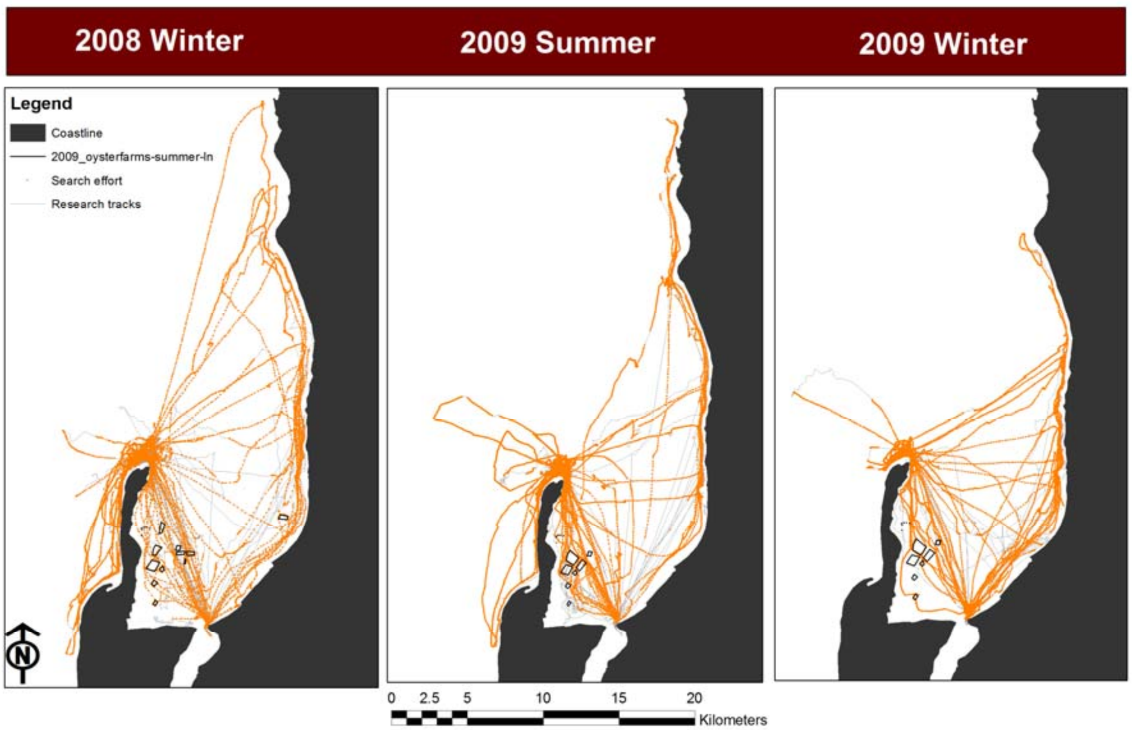

Figure 1. Study area from Walvis Bay to Swakopmund, showing 1) overall tracks of the research boat during each season worked so far (light grey lines) and 2) time spent actively searching (orange dots). Outlines of oyster farms are shown in bold black lines.

Port expansion

Since the start of the Namibian Dolphin Project, two major construction projects in the bay have been proposed by Namport, the Namibian port management authority. Firstly, the expansion of the container terminal (Fig. 2) and secondly the development of an offshore ship and oil rig repair facility in the harbour. The latter project is in early proposal stages and several potential outcomes have been proposed all of which are smaller in scale than the proposed container terminal. Both projects, but particularly the proposed container terminal expansion, are likely to have major effects on functioning of the bay ecosystem through pollution, noise and increased turbidity during both the construction phase and after completion. Further, the shape of the proposed terminal is highly likely to impact water flow patterns within the bay. This is likely to have disastrous consequences for the functioning of the local ecosystem. The inner lagoon (a major fish hatchery area and regular feeding ground for bottlenose dolphins) is likely to silt up entirely due to reduced water flow, while the sand spit forming the western side of the bay is already under threat of breaking through with waves occasionally crossing the spit in the Donkey Bay area. The NDP has registered as an IAP for both projects and expressed our concerns regarding the potential impact of the projects on the environment in general and the marine mammal fauna in particular. Dolphins and whales are acoustically sensitive and construction noises (especially explosives and pneumatic impact devices) can have potentially major impacts on these animals ranging form temporary disturbance, through permanent emigration from the area and physical injury including permanent deafness (Ketten, et al.1993, Richardson et al.1986, Richardson, et al.1995, Todd et al.1996, Barlow & Gisiner, 2006).

Figure 2 – Image is listed as *Figure 1* in the public, EIA Background information document issued by Namport in May 2009. Available in the BID from www.namport.co.na

Methods

Field Work

Data were collected primarily in Walvis Bay between (22°57'S) and Swakopmund (22°40'S), within 5 nm of shore. Several surveys were run in Lüderitz Bay (~26° 39S, 15°05E) for the collection of biopsy skin samples and deployment of acoustic loggers. Data were collected during two field seasons; summer (15 Feb – 31 March 2009) and winter (15 July to 31 Aug 2009). In the Walvis Bay area, surveys were performed on two different boats; in summer we used an 8m catamaran ski boat "*Pedro*" with twin 80HP 4-stroke Honda engines which was loaned to the project by Pelican Tours and Arrebusch lodge. This vessel wasn't available longer term and for the winter season, the project managed to secure, through a rental agreement with the owner, dedicated use of our own research vessel a 5.7m rigid hulled inflatable boat "*Nanuuq*" fitted with twin Mercury 50HP 2-stroke engines. Survey procedures were the same for both vessels, although having our own boat allowed for much greater flexibility in terms of launch and recovery times and in being able to target our effort more precisely. Survey tracks were random in direction and photographic recaptures for abundance estimation were prioritized over random surveys for habitat description. Surveys tended to either head north along the coast towards Swakopmund or on random routes across the bay towards Pelican Point. Trips along the exposed coast to the south of Pelican Point were rarer and weather dependent.

Upon sighting a group of bottlenose dolphins, they were approached and behaviour, group dispersion and direction of movement were recorded as accurately as possible (Table 2). The number of tour boats present (ski-boat or sailing catamaran) was also recorded. If more than 3 tour boats were present we stood off at >100m to reduce disturbance until the number of boats was 3 or less. This is in line with the existing code of conduct developed by MTAN. We attempted to photograph both sides of the dorsal fins of all animals but this was not always possible due to their behaviour or proximity to shore. To investigate variation in behaviour across the bay, we instituted 'dedicated' behavioural observations in which behaviour was recorded at 3min intervals for extended periods with the boat attempting to stand off at a distance that did not affect the animal's behaviour.

We photographed groups of Heaviside's dolphins in the same way as that of bottlenose dolphins. However, in the waters due north of Pelican Point, multiple small groups of Heaviside's dolphins (~1-8) aggregate with frequent fission and fusion between groups. Long dives and direction changes are frequent and animals are frequently indifferent to, or apparently avoid the boat. Distinguishing between defined groups and maintaining exclusive contact therewith as is normal in photo-ID studies is rarely possible here. In this area, we would opportunistically photograph all dolphins in any subgroups which could be approached or that approached the boat. This was defined as an encounter and all the subgroups and animals within the aggregation were counted as far as possible. When groups of Heaviside's dolphins were encountered along the coast to the north or south of the Point, they were usually in small, easily defined groups.

Whales were encountered during surveys on several occasions (Table 1). Whales were a lower priority than the focal dolphin species but photographs were collected when it was deemed that the effort would not affect the dolphin surveys or data collection. As far as possible, we would not approach whales for photography until all tour boats had moved off (i.e. we would stand off at least 100m astern maintaining visual contact and follow slowly). In 2009, skin samples for genetic analysis were collected if possible using a dart fired from a small crossbow.

Skippers of the commercial tour boats would often inform us directly of the whereabouts of groups of dolphins or whales, or they would share the location generally over VHF radio. When not otherwise engaged or limited by distance or a pre-planned survey route, we often took advantage of these reports. Our encounter rate with bottlenose dolphins and whale species was considerably improved because of this. To minimise boat traffic around dolphins, and because of the need for closer approaches for photography than the tour boats make, we attempted not to work with groups of dolphins or whales in the immediate vicinity of tour boats. Exceptions were made to try and complete photography of a group that was started before any tour boats arrived or if a group of whales was moving rapidly offshore. In all cases, we attempted to minimise disturbance to the animals through slow driving and cautious approaches and by moving off as soon as photography was complete.

Skin biopsies from Heaviside's dolphins (2009 only) were collected on as few days as possible in both Walvis Bay (4 summer, 2 winter) and Luderitz (1 summer, 1 winter) to minimise disturbance to the animals. Samples were collected with pole or Hawaiian sling fitted with a coring tip 15 or 20mm long. Samples were taken from the dorsal surface of animals while they were bowriding the boat. Disturbance was minimal, animals would move off the bow once sampled but regularly came back to bowride within minutes of the initial disturbance.

Table 1. Summary results from the three field seasons to date in Walvis Bay (these are the numbers of animals encountered from the research vessel and do not represent the total number of animals present in the bay during the study period, as only ~50% of days were spent at sea over during field seasons). Ranges indicate the sums of minimum and maximum group size counts.

Sea time	**2008 Winter**		**2009 Summer**		**2009 Winter**	
	Days	**Hours**	**Days**	**Hours**	**Days**	**Hours**
Research surveys	26 (+ 6 on tours boats)	152:07 (21:03 on tour boats)	24	137:41	25	100:31
No. ID images taken	6833		2908		2456	
Species	**No. encounters**	**No. animals**	**No. encounters**	**No. animals**	**No. encounters**	**No. animals**
Heaviside's dolphins	168	1061-1515	126	502-721	40*	218 - 329
Bottlenose dolphins	30	259-353	20	78-92	17	170 – 229
Dusky dolphins	0	0	1	6	0	0
Killer whale	1	2	0	0	0	0
Southern right whale	1	1	0	0	1	1
Humpback whale	9	16	4	4	2	2

**a different approach to working with Heaviside's dolphins was used in winter. We prolonged encounters in high density areas of multiple sub groups rather than attempting to define 'group encounters' in these areas.*

Table 2. Description of behaviour types distinguished in the field.

Behaviour	Description
Fast travelling	Animals moving briskly along the surface, usually with much splashing
Slow travelling / resting	Slow directed movement, usually no splashing, animals often tightly grouped or in sub-groups
Surface feeding	Animals usually dispersed, frequent direction changes, fish chases at the surface, seals and birds often in attendance
Subsurface feeding (possible)	Tail up dives, frequent direction changes at the surface
Milling	Slow movements at the surface, no clear direction of movement
Socialising	No directed movement, jumping, chasing
Group Dispersion	
Dispersed or tightly grouped	Tightly grouped dolphins are within 3 body lengths of each other

Spatial variation in behaviour

Spatial variation in the behaviour of bottlenose dolphins was analysed by subsampling the dedicated behavioural follow data (recorded at 3 min intervals) to 15 min intervals to reduce any autocorrelation in the data, and combining these observations with opportunistic observations taken during photo-ID encounters. In 2008, behavioural observations were only made opportunistically. The three seasons were treated separately and spatial variation was analysed at two spatial scales. The broader scale involved splitting the bay area into 4 sectors based on the distribution of oyster farms (southwest sector), harbour area (southeast sector), coastal habitat (north east sector) and open coast and Pelican Point corridor area (northwest sector). The observed distribution of socialising, resting and surface feeding behaviours was compared to an expected distribution (using a Chi squared test), based on the overall distribution of all recorded behaviours for that season to investigate spatial bias in the distribution of these behaviours. We subsequently investigated the distribution of behaviour at a finer scale by overlaying a 2x2km grid on the bay.

Abundance Estimation.

Data from the 2008 pilot season (June- July) have been fully processed, reanalysed and submitted to the Canadian Journal of Zoology for publication. Full details are available in the manuscript. Briefly: we applied the closed-population log-likelihood mark-recapture methods developed by Huggins (1989) to estimate the number of identifiable animals in the population for Heaviside's dolphins and bottlenose dolphins. Several models incorporating variation in capture probability over time and between individuals were explored. The bottlenose dolphin catalogue was maintained separately for left and right side identifications as some animals were only identified from scarring and not dorsal edge marks (although these were not included in analysis). This number (N-hat) was extrapolated upwards to the full population size by multiplying the derived estimate by the proportion of marked animals in each population.

Acoustics

The C-POD is a self-contained submersible computer and hydrophone, which recognizes and logs echolocation clicks from porpoises and dolphins (www.chelonia.co.uk). Data are stored on a removable Secure Digital Card and the instruments are powered by 10 D-cell batteries which last for up to 3 months. The C-POD uses digital waveform characterisation to select clicks and logs the time, centre frequency, intensity and bandwidth of each cetacean click. The PC software (CPOD.exe) takes the click data and finds ‘trains’ – roughly regular sequences of clicks that are characteristic of sonar systems – of either boat or cetacean origin. These click trains are then classified by the programme to distinguish cetacean trains from boat sonar (fish finders) and from trains which may arise by chance from random background sources such as propellers, sand movement and snapping shrimps. Older, analogue versions of these instruments (T-

PODs) have been widely used to describe temporal patterns of habitat use by small cetaceans (e.g. Leeney and Tregenza 2006).

Five C-PODs were secured for this project through a NACOMA "Matching Grant" with MFMR-NATMIRC. The instruments arrived in Namibia for the winter season and all 5 C-PODs were deployed in August 2009, 3 in Walvis Bay (on two moorings) and 2 in Lüderitz. All units were moored roughly 5m below the sea surface on "L-shaped" moorings consisting of a large anchor weight, 5m of chain to act as a spring, horizontal line (equal to depth), smaller stabilising weight, a vertical line (equal to spring tide high water depth at the mooring location) and a surface buoy. Two were deployed on a single mooring at Pelican Point at roughly 5m from the seabed and 5 m from the surface (~30m of water) to investigate variation in detection probabilities at different depths.

Results.

This report presents only *preliminary* results and analysis of the data collected and processed to date. Several aspects of these results are currently being analysed or written up for publication by students or PI's.

Do not cite these results without permission of the authors, please contact us for the most current results.

A similar number of surveys were run in each of the three seasons (Table 1) with search effort being spread widely (Figure 1). Hours at sea decreased over the three field seasons as we became more familiar with the environment and were able to better target surveys to higher density areas and times (further aided by having our own boat in the last season). The number of encounters and individual animals seen varied considerably between the three seasons. During the pilot study, effort was focussed primarily on Heaviside's dolphins. However, in 2009, the project focus shifted more towards bottlenose dolphins. This was as a result of our experience with the study animals, the environment and evaluation of the relative threats to each species. The bottlenose dolphins use the interior of the bay more frequently, are a much smaller population, with predictable behaviour and are much more impacted by tourism as well as coastal development within the bay and coastal zone.

Although less effort was targeted at Heaviside's dolphins during the winter 2009 season, the lower number of encounters also reflects the longer duration of encounters defined, rather than being entirely an artefact of dolphin numbers. However, we did note that Heaviside's dolphins and all whale species were encountered less frequently in 2009 than during the pilot study, a sentiment echoed by the tour boat skippers, reasons are currently unclear. The behaviour of Heaviside's dolphins in Walvis Bay makes photo-ID challenging as it is necessary to approach animals closely to get a good quality image of the dolphin's dorsal fin. In other parts of their range, including Lüderitz, Heaviside's dolphins are generally very boat friendly, whereas in Walvis Bay they are frequently quite evasive towards the boat, probably as a result of feeding (a behaviour not seen close to shore in South Africa). It is very difficult to get good quality photo-ID images when the dolphins are being evasive or not approaching the boat and the majority of our images are obtained on days when animals are socialising, playing and bowriding. Such days were considerably more numerous in 2008 than in 2009, for reasons that are not yet clear. We hope that the long term data generated by moored hydrophones at Pelican Point will allow us to unravel the link between dolphin presence and behaviour with possible influences by currents, wind, upwelling and diurnal and lunar patterns (etc).

Bottlenose dolphin groups were considerably smaller in summer (mean 4.1) than in winter (mean 9.8 in 2008 and 10.0 in 2009). Large groups of up to 30 were seen regularly in winter months but never in summer where the largest group seen was 9 animals.

Distribution patterns for both dolphin species varied considerably between the summer and winter field seasons. Heaviside's dolphins were mainly (almost exclusively in winter months) clustered around the Pelican Point area (Figure 2). In summer, sightings of Heaviside's dolphins in the bay, along the east coast and out to sea were far more common. The distribution pattern of bottlenose dolphins varied between seasons with only the east coast area (Bird Island to Long Beach), being used consistently in all seasons (Figure 3). Sightings of bottlenose dolphins at Pelican Point were regular in all seasons but the animals tended to be passing through or moving away from the area and the relatively high encounter rate here reflects both our high search effort in the region and that this area acts as a corridor for bottlenose dolphins passing between the bay and the coast to the south. Most noticeable is the difference in distribution patterns within the bay itself – sightings were almost exclusively clustered around the oyster farms in summer (48% of time with bottlenose dolphins in this quadrant), but far less frequently in the two winter seasons (30% and 17% of time for 2008 and 2009 respectively). The two winter seasons are not directly comparable as many of the oyster farms which were active during the 2008-winter season shut down during and after this time due to the effects of large sulphur blooms and red tide events killing off a reported ~90% of the 2008 oyster crop.

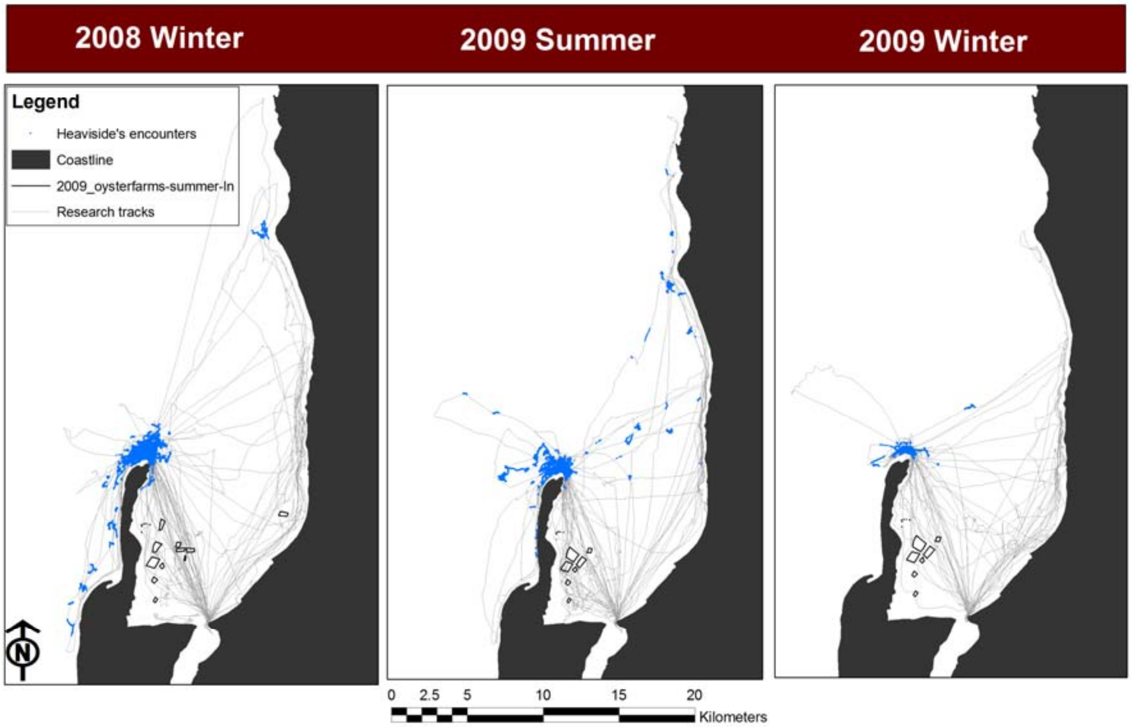

Figure 3. Distribution of Heaviside's dolphins in Walvis Bay in all three field seasons worked. Blue dots are GPS tracks from the boat during time spent with Heaviside's dolphins. All boat tracks for the season (grey lines) are also displayed to indicate survey effort.

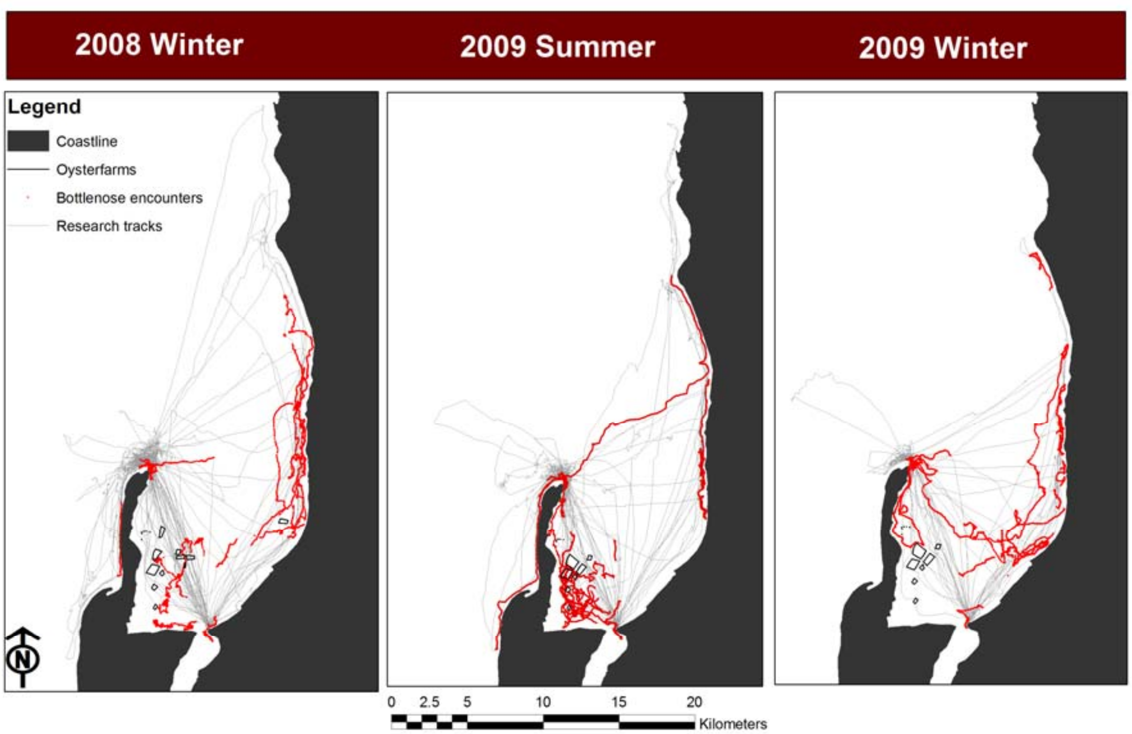

Figure 4. Distribution of bottlenose dolphins in Walvis Bay in all three field seasons worked. Red dots are GPS tracks from the boat during time spent with bottlenose dolphins. Overlain on all boat tracks for the season (grey lines) to indicate research effort.

Abundance

Abundance estimates do not yet include data collected in 2009 for either species, although the data from the 2008 pilot study were fully checked, reanalysed using the most current methods and have been submitted for publication (see "Outputs" section). Summary results are presented below for bottlenose (Table 3) and Heaviside's dolphins (Table 4). Mark-recapture estimates applied to identifiable animals (68% of the bottlenose and 18% of the Heaviside's dolphin populations) were extrapolated to full population size. The lower CI's were in some cases below the total number of animals in the full catalogue, in this case we assumed the number of animals in the catalogue was the correct minimum number of animals in the population, resulting in estimates from the left and right side catalogues of 77 (71-122) and 78 (71-119) bottlenose dolphins and single estimate of 505 (335-764) Heaviside's dolphins using the study area during the 2008 study period. Preliminary analysis of photo-ID data have confirmed matches of individuals from both species between years and seasons showing long term site fidelity of at least some animals to the area.

Table 3. Results of mark-recapture analyses of bottlenose dolphins for the left and right side catalogues. Models fitted were the null model (M_0), time varying capture probability (Mt) and 2 mixture variation in individual capture probability (Mh) and a time and individual varying model (Mth). Best fitting models are indicated by an *. Theta for extrapolating N-hat (mark-recapture estimate) to N_{tot} (total population size) is 0.68 (left side catalogue) and 0.67 (right side catalogue). Analyses run in program R, using package *mra* (McDonald, 2008).

	Mark-recapture estimates				Total population size			
LEFT SIDE	N-hat	SE	CV	AIC	N-tot	SE/Var	CI low	CI high
M_0	50	1.36	0.04	854.44	73	101.31	56	96
Mt	49	1.14	0.03	747.69	73	84.24	57	93
Mh (2 groups)	53	3.02	0.17	822.60	78	238.25	54	115
Mth (2 groups)*	52	2.20	0.09	669.92	77	171.33	56	107
RIGHT SIDE								
M0	48	1.70	0.06	786.65	72	11.14	54	98
Mt	48	1.38	0.04	674.61	71	9.98	54	94
Mh (2 groups)	54	4.15	0.32	750.04	81	18.31	52	125
Mth (2 groups)*	52	3.62	0.25	631.50	78	16.88	52	119

Table 4. Results of mark-recapture analyses of Heaviside's dolphins for the left and right side catalogues. Models fitted were the null (M_0), time varying capture probability (Mt) and 2 mixture variation in individual capture probability (Mh) and a time and individual varying model (Mth). Best fitting models are indicated by an *. Theta for extrapolating N-hat (mark-recapture estimate) to N_{tot} (total population size) is 0.18. Analyses run in program R, using package *mra* (McDonald, 2008)

	Mark-recapture estimates				Total population size			
Heavisides	N-hat	SE/Var	CV	AIC	N-tot	SE/Var	CI low	CI high
M0	67	12.25	2.23	394.29	383	68.99	270	544
Mt	66	11.61	2.06	377.33	372	66.25	263	526
Mh (2 groups)	92	24.01	6.27	370.09	523	112.42	345	793
Mth (2 groups)*	89	22.73	5.81	351.11	505	107.60	335	764
Mh (D-values)	85	27.97	9.23	392.00	481	116.41	302	768
Mth (D-value)	82	27.25	9.03	374.96	467	113.20	293	746

Spatial variation in behaviour

Although sample sizes were small in each season, it is clear that the behaviour of bottlenose dolphins varied across the bay and between seasons. Socialising behaviour was observed in all four sectors of the bay but showed no predictable pattern between seasons (Fig 5).

Surface feeding was seen most frequently in the vicinity of the oyster farms (SW sector), particularly in the 2008 winter and 2009 summer seasons with the NW sector being the second most important feeding area (Fig. 6). It is quite noticeable that during the 2009 summer field season, not just the feeding behaviour observed, but the overall distribution of bottlenose dolphins was strongly biased towards the area around the oyster farms (Fig 4), whereas in winter 2009, they were rarely seen in this area.

Resting behaviour of bottlenose dolphins was most frequently observed in the northeast sector, in the area between Bird Island and Long Beach (Fig. 7). In this area, dolphins were frequently seen very close to shore, in the breaker zone where they were very difficult to approach by boat.

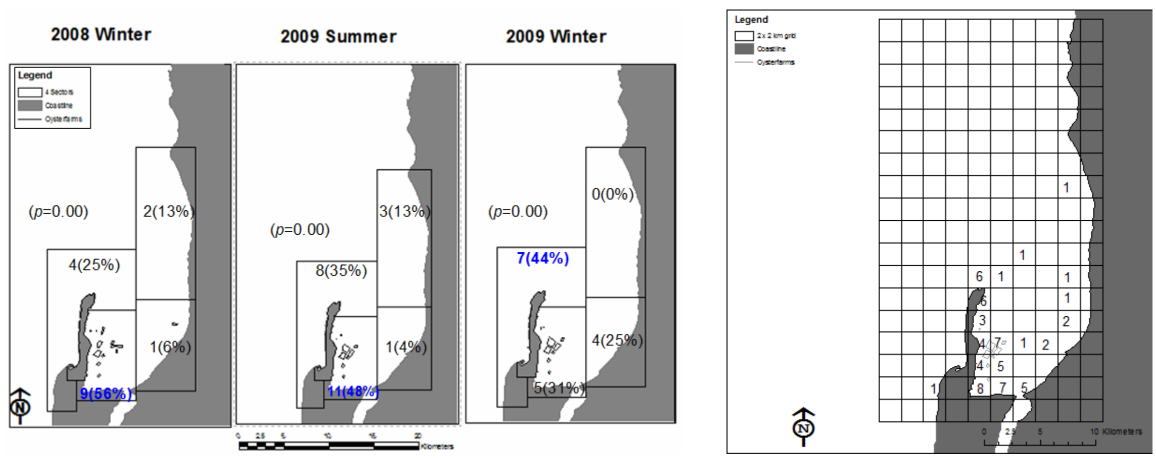

Fig. 5. Three maps to left hand side illustrate the seasonal distribution of **socializing behaviour** of bottlenose dolphins in four sectors of Walvis Bay, Namibia as number of observations (and percents). Values in bold-blue indicate where socializing predominantly occurred. P-values indicate results of chi-squared test comparing the distribution of socialising behaviour to the overall distribution of all behavioural observations. The map on the right shows the distribution of observations at a finer spatial scale (a 2x2km grid) for all 3 seasons combined.

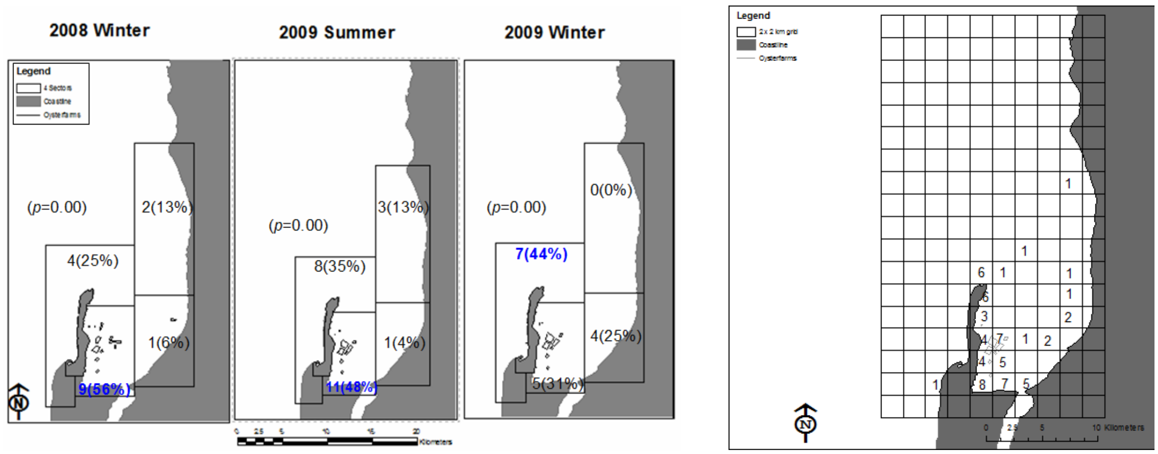

Fig. 6. Three maps to left hand side illustrate the seasonal distribution of **surface feeding behaviour** of bottlenose dolphins in four sectors of Walvis Bay, Namibia as number of observations (and percents). Values in bold-blue indicate where surface feeding predominantly occurred. P-values indicate results of chi-squared test comparing the distribution of surface feeding behaviour to the overall distribution of all behavioural observations. The map on the right shows the distribution of observations at a finer spatial scale (a 2x2km grid) for all 3 seasons combined.

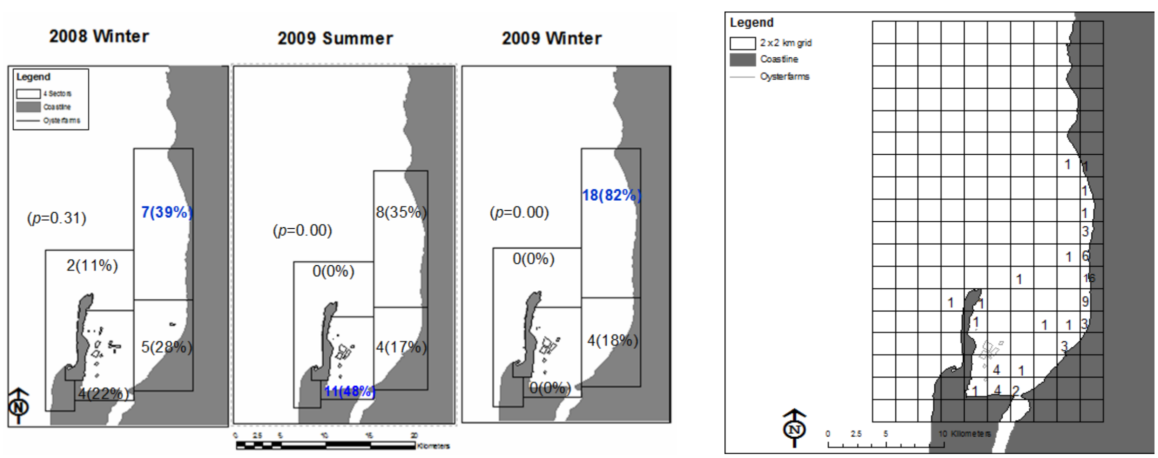

Fig. 7. Three maps to left hand side illustrate the seasonal distribution of **resting behaviour** of bottlenose dolphins in four sectors of Walvis Bay, Namibia as number of observations (and percents). Values in bold-blue indicate where resting predominantly occurred. P-values indicate results of chi-squared test comparing the distribution of resting behaviour to the overall distribution of all behavioural observations. The map on the right shows the distribution of observations at a finer spatial scale (a 2x2km grid) for all 3 seasons combined.

Biopsy work

Skin biopsies were collected from 3 humpback whales (1 was stranded) and 1 southern right whale. These samples were split into genetic and stable isotope samples and are being held until sample sizes justify analysis. Samples from humpback whales will be invaluable in shedding light on the population structure and identity of the animals passing through Namibian waters; it is not currently known if these whales belong to the populations breeding of Angola (B2) or west Africa (B1). Samples from right whales will allow for investigation of broad scale population structure in this recovering population.

Skin biopsies were also collected from 1 free swimming bottlenose dolphin and 17 Heaviside's dolphins in Walvis Bay and in Lüderitz: 17 Heaviside's dolphins. These samples have each been split for multiple analyses to maximise the use of each sample. A further 16 skin samples were collected from the group of bottlenose dolphins that stranded in Walvis Bay on the 16th March 2009 – these samples are in the possession of Heidi Skrypzeck at MFMR – Natmirc and are not currently regarded as part of this project or its results.

The blubber portion of biopsies will be used to investigate dietary differences between sites and seasons in collaboration with the Scottish Association for Marine Science.

Skin samples have been split into 4.
1) We will analyse the variation in the stable isotopes of carbon and nitrogen to investigate population structure and trophic level variation across site and season, in collaboration with the Scottish Association for Marine Science.

2) Sulphur isotopes will be analysed as part of a larger MFMR project (JP Roux and colleagues).

3) Heavy metal pollution in coastal delphinids around southern Africa is being investigated by Dr Victoria Tornero of the University of Pretoria.

4) Lastly we are exchanging isotope for genetic samples with Keshni Gopal and Leszek Karcsmarzki (University of Pretoria) to substantially enlarge the spatial range of each study. Ms Gopal will be investigating population structure and dispersal across the range of the Heaviside's dolphins using genetic techniques.

Thus, each sample taken from an animal is being used to its maximum effect in a range of studies that are central to understanding the population structure, diet and ecological interactions of these species.

Acoustics

The five C-PODs only became available for the winter field season in 2009 and were deployed in two locations in Walvis Bay (two at Pelican Point, one just 1km off Aphrodite Beach) and two in Lüderitz Bay (in Guano Bay and Shearwater Bay). No data is as yet available for this report as the C-PODs are deployed on a 3 month cycle with the first battery change / data download only scheduled for December 2009. Results from the pilot study using the analogue T-POD and the newer digital C-POD have been written up for publication (see "Outputs" section).

Briefly, both instruments proved to successfully record the presence of Heaviside's and bottlenose dolphins. This is the first time that these instruments have been used to detect Heaviside's dolphins, and is the first structured use of these tools in an African country. The frequency of the Heaviside's dolphin clicks was largely in the 120-140 kHz range, and the distribution of click frequencies recorded by the C-POD was unimodal, in contrast to the bimodal energy distribution often seen in clicks received from some dolphin species. A distinct diel pattern to the mean hourly inter-click interval (the rate at which animals produce clicks) was observed, with higher values during daylight hours than at night; however there was no apparent diel pattern in the proportion of feeding buzz trains produced. A diel pattern in overall click activity was also observed, with many more detection-positive minutes per hour between dusk and dawn, and vocalization activity dropping to low levels in the middle of the day (Figure 8); this corresponded with visual observations made on abundance of dolphins in the study area. Static Acoustic Monitoring proved to be an effective technique for monitoring habitat use by Heaviside's dolphins.

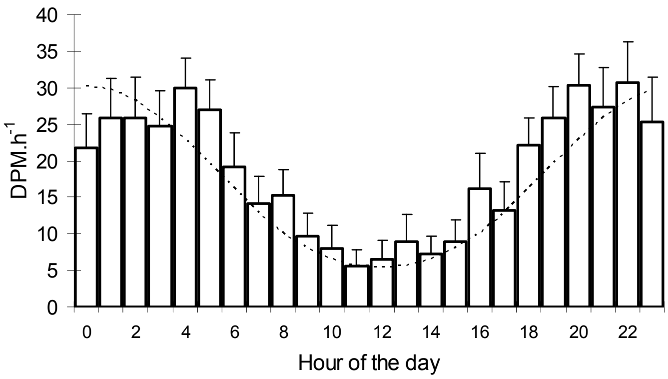

Figure 8. Diel patterns in the detection of Heaviside's dolphin sounds at one location in Walvis Bay, Namibia, monitored by a T-POD. Mean (+ s.e.) hourly detection rates (detection-positive minutes per hour; DPM.h^{-1}), June 28-July 3 & July 16 - 25, 2008 (n = 14 for most hours; minimum n = 8). Average sunrise and sunset times were 06:30 and 17:23 respectively. The dotted line represents the fitted sinusoid curve.

Strandings

We attended two stranding events in the Walvis Bay region, a mature humpback whale on the 14 March 2009 (the animal stranded live on the 11th March) and a mass stranding of 19 bottlenose dolphins in the inner lagoon on the 16 March 2009. Both events were also attended by MFMR (Heidi Skrypzeck) and CETN (John Paterson). The timing was unfortunate for both strandings events; we were not in the country when the humpback whale stranded alive and only visited it to collect samples and measurements several days after it had died on the beach. The bottlenose dolphins were trapped in shallow water in the south end of the lagoon on a day we were out of town and were only able to get back to Walvis Bay at the every end of the day when the majority of animals had moved out of the lagoon.

Both events involved live animals and generated a considerable amount of press and community involvement. However, all feedback recognised that organisation, training and equipment were lacking at both events. The potential negative media fallout from large live strandings events was further highlighted by the mass stranding of ~54 false killer whales (*Pseudorca crassidens*) at Kommetjie Beach near Cape Town in June 2009. Recognising the importance of having a well trained and equipped strandings response team the NDP and CETN applied for and were granted N$27 280 from the Walvis Bay Municipality Enviro-Fund for the "Development of a marine mammal and turtle strandings response network in Walvis Bay".

These funds are to be used to:
1) Identify potential core members of the strandings network and routes of communication.

2) Run workshops for core members and all interested participants in the community. Workshops will include species identification, background information on species, health assessment, rescue methods, data and sample collection and carcass disposal options.

3) Equip a strandings response team with the relevant equipment for the rescue of stranded animals, crowd control and data collection.

4) Inform the local community of the existence of the network and relevant contact points through media releases and information at key sites (information boards).

Items one and two have already been addressed by the hosting of a workshop in Walvis Bay on 31 Aug 2009, involving key participants from local tour operations, MFMR (S. Iikela) and CETN. Items three and four are in progress.

Project Outputs

Scientific papers and conference presentations.

Leeney, RH, Carslake, D and Elwen SH (Submitted – Mar Mamm. Sci.). Using Static Acoustic Monitoring to describe echolocation behavior of Heaviside's dolphins in Namibia.

Leeney, RH, Carslake, D and Elwen SH 2009. Using static acoustic monitoring to describe the echolocation behaviour of Heaviside's dolphins in Namibia. Poster presented at the18th Biennial Conference on the Biology of Marine Mammals, Quebec City, Quebec 12-16 Oct 2009.

Elwen, SH, Bester, M and Leeney, RH. (In review - Can J Zool). Investigation of sources of heterogeneity in the capture-probability of two sympatric coastal dolphins: Implications for mark-recapture analysis.

Elwen, SH, Paterson, J. Skrypzeck, H and Weir, C (In prep for Aquatic Mammals). A mass stranding event of a coastal population of bottlenose dolphins (*Tursiops truncatus*) in Walvis Bay, Namibia – implications for coastal development and population survival.

Capacity Building & Training

1) Workshop and training to the core members of the Walvis Bay Strandings response team on 31 August 2009. See Appendix 1 for full participant list.

2) Office and sea-based training to Johannes Iitembu (MFMR – co-investigator) and Sion Iikela (MFMR – marine mammal technician, NATMIRC) and Dr Jean-Paul Roux (MFMR-Lüderitz) on how to use, set up deploy and download data from C-POD hydrophones.

3) No Namibian students were taken on this year due to inability to commit longer term at the beginning of the year. This was a result of one of our major funders threatening to pull our funding. Fortunately, this was cleared up with invaluable help from Dr Chris Brown and Ms Rachel Malone at the NNF, but by the time our funding was secured, all U.Nam 4th year students had already committed to other projects.

4) Theodore Meyer is an Honours (4th) year student at the University of Pretoria. He investigated habitat related behavioural variation in bottlenose dolphins as a precursor to developing a spatially delineated management scheme. Thesis title: Managing human-dolphin conflict through the investigation of critical habitats of bottlenose dolphins (*Tursiops truncatus*).

Summary & Discussion

This report provides a summary of the NDP work and findings to date with focus on the 2009 field season. ***For all aspects of the project, results should be considered as preliminary with work ongoing.***

Three seasons of data have clearly shown that there is significant seasonal variation in the distribution of Heaviside's and bottlenose dolphins in the Walvis Bay region and confirm the results from the pilot study that these species use different parts of the environment. Heaviside's dolphins were never seen in the bay itself except close to Pelican Point, but were seen fairly regularly along the open coasts outside the bay, generally in deeper water (>20m). Heaviside's dolphins were predominantly seen at Pelican Point in all seasons and acoustic monitoring confirms their presence here 24 hours a day with potentially more animals present at night than in the day.

Bottlenose dolphins on the other hand were sighted throughout the bay, and very close to shore (<1nm and often within the breaker zone) along the coast to the north and south. We shall discuss the implications of habitat choice for each area separately. Distribution within the bay itself differed considerably between seasons with animals being seen regularly near the oyster farms in winter 2008, almost exclusively around the oyster farms in summer 2009 but only once during the winter of 2009 when their distribution within the bay was predominantly on the east side between the breakwater wall and Bird Island. We can interpret these results in light of variation in the local environment and the potential influences of the oyster farms on dolphin presence.

The northern Benguela is more seasonal than the southern Benguela with the strongest upwelling and environmental enrichment occurring in the winter and spring months. In summer, wind and therefore water column mixing is weaker and the environment is generally poorer in nutrients (Shannon, 1989). Added to these factors, was a series of strong sulphur blooms in Walvis Bay during late summer (pers obs) which are both poisonous and create hypoxic conditions (Weeks et al. 2004) likely to reduce animal life in the vicinity. In nutrient poor environments such as the Mediterranean, bottlenose dolphins are known to be attracted to the areas around fin-fish farms due to the higher abundance and variety of wild fish attracted to the nutrient rich area close to the farm (Diaz-Lopez et al. 2005). It seems likely that during the relatively nutrient poor summer months in Walvis Bay, a similar effect is occurring. Although farmed oysters are not fed or medicated, they are filter feeders and act as nutrient concentrators by defecating. The lines and buoys of the farms may also act as fish aggregating devices by creating artificial reefs which are attractive to fish. The apparently reduced attraction of oyster farms between the two winters is likely to be due to the greatly reduced number of active farms in the bay in 2009. Although considerably fewer farms were active, the majority of the lines and buoys were still in place, suggesting that it is environmental enrichment due to faeces that attracts fish to the area more than any artificial reef effect of the lines themselves. These differences imply that the oyster farms have a considerable (if unnatural) effect on the distribution of bottlenose dolphins in Walvis Bay.

The only area of significant overlap between the Heaviside's and bottlenose dolphins was at Pelican Point. Fine scale hydrographic effects at the Point, resulting from the clockwise moving currents leaving the bay and mixing with water from the open sea may act to predictably aggregate fish species that are suitable prey for Heaviside's dolphins. Bottlenose dolphins sighted at Pelican Point were usually travelling through the area, although occasional feeding was observed. Given the shallow-water preference of this population, it seems likely that the Pelican Point area acts as an important 'corridor' for dolphins moving from the bay to the southern coast. We conclude that the Pelican Point area is an important one for both dolphin species and it must be highlighted as a key conservation area for these species as well as the many sea birds which aggregate in this region.

The one area used consistently by bottlenose dolphins in all seasons was the near shore, reef area between Bird Island and Long Beach. Although reef areas are often associated with dolphin feeding (Karczmarski et al. 2000b), the predominant activity seen in this part of the study area was resting. Resting behaviour is of biological importance to any animal and in dolphins, is known to be highly susceptible to disturbance (Lusseau 2003, Wursig 1996). In this area, dolphins were frequently in the wave zone and often so close to shore that approaching them for photography was not possible. This surf and reefs in this area may thus act as a refuge of sorts for the bottlenose dolphin population in Walvis Bay. This is further supported by the observation that the semi-stable group of mothers with calves were seen more regularly here than elsewhere in the bay. We aim to investigate both social relationships and individual variation in home range use in this population next season.

A C-POD hydrophone has now been deployed at Aphrodite beach (~2km north of the Bird Island in 10m of water). This instrument is collecting data on dolphin presence and absence 24 hours a day thereby allowing us to ascertain the relative importance of this area to bottlenose dolphins throughout the full daily cycle.

Two hydrophones are placed on a single mooring at Pelican Point. These instruments will collect data on both Heaviside's and bottlenose dolphins over the 24-hour cycle. We aim to keep all instruments in the water for as long as is feasible, their first battery change and download is due in December 2009. By using two instruments in a vertical array we will be able to describe detection differences at different C-POD deployment depths.

The way forward

In 2010, the Namibian Dolphin Project will continue its core data collection in Walvis Bay and Lüderitz, and will further develop the training and capacity-building of the strandings network along the coast. Acoustic data collection will be continuous over this time, and training of local staff in management of the hardware and data downloading will be completed, in order that these tasks can be run continuously and independently of the presence of the Namibian Dolphin Project team. If funding and personnel time allows, a WiSe Scheme course (http://www.wisescheme.org/index.html) will be run for the marine wildlife tour companies operating in Walvis Bay, as a first step towards increasing the sustainability of the operations of this sector, an important contributor to the tourism industry in Namibia.

Acknowledgements

This project could not have been as successful as it has been without all the support we received from everyone in Namibia. We must thank: Chris Brown, Rachel Malone and Sally Wood of the NNF for all the support they have given us through our affiliation to their great organisation. Jean Paul Roux, Heidi Skrypzeck, Sion Iileka and Johannes Iitembu of MFMR, Rod Braby and Nathalie Cadot of NACOMA, John and Barbara Paterson for housing and supporting us, both through CETN and in a personal capacity. Naude Dreyer of Sandwich Harbour tours, Neels and Megan Dreyer of Mola-Mola tours. Alan Louw, Flossie van Rensburg, Andries Prinsloo of Namib Diving and Marine. Everyone at Catamaran Charters and Levo Tours. All the tour operators that returned questionnaires and the skippers that passed on information at sea.

Special thanks to Ingo and Isolde Venter of Pelican Tours; Arebbush Lodge and Catamaran Charters for the invaluable loan of *Pedro* and for assistance in the field in 2008 and early 2009.

This research would not be possible without funding from the following sources:

The Rufford Small Grants Foundation to SE
A British Ecological Society Small Ecological Project Grant to RHL
A British Ecological Society Overseas Bursary to SE
The Nedbank Go Green Fund of Namibia to SE & RHL
A NACOMA Matching Grant to RHL & SE
A Walvis Bay Municipality Enviro-fund grant to SE & RHL
Generous donations from the local community in Provincetown, MA, USA to RHL.

Literature cited

Barlow, J, Gisiner, R. 2006. Mitigating, monitoring and assessing the effects of anthropogenic sound on beaked whales *Journal of Cetacean Research and Management* 7: 239-249.

Bejder L, Samuels A, Whitehead H, Gales N, Mann J, Connor R, Heithaus M, Watson-Capps J, Flaherty C, Krützen M. 2006. Decline in Relative Abundance of Bottlenose Dolphins Exposed to Long-Term Disturbance. *Conservation Biology* 201: 791-798.

Brown, P.C, Painting, S.J., Cochrane, K.L 1991. Estimates of phytoplankton and bacterial biomass and production in the northern and southern Benguela ecosystems. *S.Afr. J. Mar. Sci* 11: 537-564.

Corkeron PJ. 1995. Humpback whales (Megaptera novaeangliae) in Hervey Bay, Queensland: behaviour and responses to whale-watching vessels. *Canadian Journal of Zoology* 73: 1290-1299.

Diaz-Lopez B, Bernal-Shirai J. 2007. Bottlenose dolphin (Tursiops truncatus) presence and incidental capture in a marine fish farm on the north-eastern coast of Sardinia (Italy). *Journal Of The Marine Biological Association Of The United Kingdom* 87: 113-117.

Diaz-Lopez B, Marini L, Polo F. 2005. The impact of a fish farm on a bottlenose dolphin population in the Mediterranean Sea *Thalassas* 21: 65-70.

Elwen S, Meyer MA, Best PB, Kotze PGH, Thornton M, Swanson S. 2006. Range and movements of female Heaviside's dolphins (*Cephalorhynchus heavisidii*) as determined by satellite linked telemetry. *Journal of Mammalogy* 87: 866-877.

Elwen SH. 2008. The distribution, movements and abundance of Heaviside's dolphins in the nearshore waters of the Western Cape, South Africa. PhD Thesis. University of Pretoria. 208pp

Elwen SH, Leeney RH. 2008. *Report of the Namibian Dolphin Project pilot study, June-July 2008.*

Findlay KP, Best PB, Ross GJB, Cockcroft VG. 1992. The distribution of small odontocete cetaceans off the coasts of South Africa and Namibia. *South African Journal of Marine Science* 12: 237-270.

Janik VM, Thompson PM. 1996. Changes in surfacing patterns of bottlenose dolphins in response to boat traffic. *Marine Mammal Science* 12(4): 597-602.

Karczmarski L, Cockcroft VG, Mclachlan A. 2000. Habitat use and preferences of Indo-Pacific humpback dolphins *Sousa Chinensis* in Algoa Bay, South Africa. *Marine Mammal Science* 16: 65-79.

Kemper CM, Gibbs SE. 2001. Dolphin interactions with tuna feedlots at Port Lincoln, South Australia and recommendations for minimising entanglements. *Journal of Cetacean Research and Management.* 3: 283-292.

Ketten, D.R, Lien J., Todd, S. 1993. Blast injury in humpback whale ears: evidence and implication. *Journal Of The Acoustical Society Of America* 94: 1849-1850.

Kruse S 1991. Dolphin Societies: discoveries and puzzles*Dolphin Societies: discoveries and puzzles.* Pryor K, Norris KS (Eds). University of California Press. 149-159

Lusseau D 2005. Residency pattern of bottlenose dolphins Tursiops spp. in Milford Sound, New Zealand, is related to boat traffic. *Marine Ecology Progress Series* 295 265-272.

Lusseau D, Higham JES. 2004. Managing the impacts of dolphin-based tourism through the definition of critical habitats: the case of bottlenose dolphins (Tursiops spp.) in Doubtful Sound, New Zealand *Tourism Management* 25: 657-667.

Lusseau D. 2003. Effects of Tour Boats on the Behavior of Bottlenose Dolphins: Using Markov Chains to Model Anthropogenic Impacts *Conservation Biology* 17: 1785-1793.

Natoli A, Peddemors VM, Hoelzel AR. 2004. Population structure and speciation in the genus Tursiops based on microsatellite and mitochondrial DNA analyses. *Journal of Evolutionary Biology* 17: 363-375.

Pichler FB, Dawson SM, Slooten E, Baker CS. 1998. Geographic isolation of Hector's dolphin populations described by mitochondrial DNA sequences. *Conservation Biology* 12(3) 676-682.

Richardson WJ, Würsig B, Greene CR. 1986. Reactions of bowhead whales, *Balaena mysticetus*, to seismic exploration in the Canadian Beaufort Sea. *The Journal of the Acoustical Society of America.* 79(4) 1117-1128

Richardson, W.J, C.R. GJ, Malme, C.I., Thompson, D.H. 1995 *Marine mammals and noise.* Academic Press, San Diego

Shannon, LV. 1989. The Physical Environment. *Oceans of Life off Southern Africa* Payne A, Crawford R(eds), Vlaeberg Publishers, Cape Town 12-27.

Todd S, Stevick P, Lien J. 1996. Behavioural effects of exposure to underwater explosions in humpback whales (*Megaptera novaeangliae*). *Canadian Journal of Zoology*74(9) 1661-1672.

Van Parijs SM, Corkeron PJ. 2001. Vocalizations and behaviour of Pacific Humpback Dolphins *Sousa chinensis*. *Ethology* 10(7): 701-716.

Watson-Capps JJ, Mann J. 2005. The effects of aquaculture on bottlenose dolphin (*Tursiops sp*.) ranging in Shark Bay, Western Australia. *Biological Conservation.* 12(4): 519-526.

Weeks SJ, Currie B, Bakun A, Peard KR. 2004. Hydrogen sulphide eruptions in the Atlantic Ocean off southern Africa: implications of a new view based on SeaWiFS satellite imagery. *Deep Sea Research Part I: Oceanographic Research Papers* 5(1): 153-172.

Williams R, Trites AW, Bain D. 2002. Behavioural interactions of killer whales (*Orcinus orca*) to whale-watching boats: opportunistic observations and experimental approaches. *Journal of Zoology (London)* 25 (6) 255-270.

Wursig B. 1996. Swim-with-dolphin activities in nature: Weighing the pros and cons. *Whalewatcher* 30: 11-15

Appendix 1. Namibian Strandings Network Contact list (Walvis Bay sector)

Name	Company/ Organisation	Telephone number	Email
Neels Dreyer	**Mola Mola**	**081 124 2522**	
John & Barbara Paterson	**CETN**	**081 148 7120 / 081 149 0051**	**john@paterson.alt.na**
Naude Dreyer	**Sandwich Harbour Tours**	**081 149 7377**	**naude15@hotmail.com**
Peter Bridgeford	**CETN**	**081-260-7375 / 064 220 443**	**pmbridge@iway.na**
Wally Hansen	Sandwich Harbour Tours	081 234 0212	the.wally@hotmail.com
Simon Wearne	Sandwich Harbour Tours	081 451 9996	simonwearne@yahoo.com
Tony van Tonder	Sandwich Harbour Tours	081 373 7604	tonyvt@gmail.com
Herman van Zyl	Sandwich Harbour Tours	081 127 2875	PVM@iway.na
Rudolf Hass	Sandwich Harbour Tours/ Mola Mola	081 335 6900	RudolfHass@gmail.com
Nik Vilpan	Sandwich Harbour/ MM	081 277 8993	
Christo Swart	Mola Mola	081 129 0323	tatoosh4@gmail.com
Allan Langenstrassen	Pelican Tours	081 356 7506	
Sanel Kenger	Mola Mola	081 400 9049	sanelkenger@yahoo.com
Charmaine & Anton Vosloo	Mola Mola	081 127 2522	info@mola-namibia.com
Eduard du Toit	Mola Mola	081 260 8776	acconts@mola-namibia.com
Walter Schäfer	Mola Mola	081 127 6691	willas@iway.na
Nico Robberts	Sandwich Harbour Tours	085 556 1196	
OTHER LOCAL CONTACTS :			
Sion Iikela	MFMR Swakopmund	081 127 6505/ 081 239 7345	siikela@mfmr.gov.na
Johannes Iitembu	MFMR Swakopmund	081 149 2949	jaiitembu@mfmr.gov.na
Stanley Beukes	Namport	081 148 3805	s.beukes@namport.com.na
Rod Braby	**NACOMA, Swakopmund**	**081-246-0996**	**rbraby@nacoma.org.na**