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The Namibian Dolphin Project 2010

Ecology and conservation of coastal dolphins in Namibia

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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

WBSN – Walvis Bay Strandings Network

Executive Summary

The coastal delphinids of Namibia have been poorly studied to date and little information exists 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, port expansion and the large marine ecotourism industry in the Walvis Bay area.

This report summarises the research and preliminary analyses of the Namibian Dolphin Project (NDP) until the end of 2010. The primary field site for the project is Walvis Bay (WB), with a secondary field site in Lüderitz (LDZ). At both sites the project has used visual surveys, photo-ID and static acoustic monitoring to investigate the distribution, habitat use, and abundance of bottlenose and Heaviside's dolphins between 2008 and 2010. The Walvis Bay marine tourism industry is assessed relative to 2008. Data on stranded whales and dolphins (current and historic) from Walvis Bay and Möwe Bay are being collated and are available from the authors.

Visual habitat surveys over five seasons in Walvis Bay and two seasons in Lüderitz have shown clear, predictable patterns of distribution and habitat use by Heaviside’s dolphins. In both study sites, Heaviside’s dolphins occupy small (~2nm^2) concentration areas at Pelican Point (WB), Guano Bay (LDZ) and Shearwater Bay (LDZ). Sightings outside these areas are rare and no comparable concentration areas have been found for 10s of km in either direction at either site. In WB, sightings away from Pelican Point are more common in summer than winter months. Static acoustic monitoring has shown the attendance pattern of Heaviside's dolphins at WB and LDZ to be opposite in nature. At WB, detections of dolphins are more numerous during night time, while at LDZ they are more numerous in daylight hours. These attendance patterns are most likely related to different foraging behaviours at the two sites. Observations of feeding as well as socialising and resting within WB and LDZ concentration sites strongly suggest that these are critical habitat areas for the species. The marine tourism industry also targets Heaviside’s dolphins at Pelican Point (WB) where they can be exposed to up to 14 tour boats simultaneously. Although high, this exposure to boats is relatively brief (2.5-3.5 h) relative to the 24-hour use of the area by dolphins. Further work is needed to investigate direct behavioural effects and data are currently being analyses to investigate long term residency.

The small population (<100) of common bottlenose dolphins which use Walvis Bay have been previously emphasised as being of primary conservation concern due to their small population, high residency and exposure to multiple threats within the bay. Analysis of the sighting histories of 88 identified individuals shows evidence for emigration from the WB area by ~19 individuals after 2008 (never seen again) and immigration of ~16 new animals in 2009 (seen in most seasons since). Uncertainty in numbers is due to possible misidentification of poorly marked animals. There has been a marked 6-8% annual reduction in the number of animals identified using the bay since 2008. Roughly twice as many individuals are identified in winter than in summer. The photographically confirmed identification of 8 individuals in LDZ doubles the known range of the population and suggests range expansion may be occurring (all these animals were subsequently resighted in WB). However, since 2008, 2 calves have been born while 2 calves and up to 4 adults have died (stranded or reported). Combined, these results suggest both the emigration of some animals from Walvis Bay and a possible decline in the total population size. Both suggestions are seriously concerning.

The existence of critical habitats (such as those used for resting and feeding) for bottlenose dolphins has been investigated by analysing the distribution and behavioural use of the bay. Although there was considerable seasonal variation in habitat use, Pelican Point and the Aphrodite-Long Beach area on the east of the bay were used frequently in all seasons, primarily for feeding and resting respectively. Further, these areas were used by the majority of individual dolphins in each season suggesting they are important to the population as a whole. The east coast area has been identified as the optimal location for a protected area in which tourism and other human activities could be reduced and managed more directly. Reduced use of this area has already been suggested to and provisionally accepted by the tourism industry (Nov 2010).

The WB tourism industry has grown since 2008 from 25 vessels to 27 vessels (5 sailing catamarans, the remainder power boats) run by 7 companies. Three kayaking companies (up from 2 in 2008) also operate. There has been a general move in the industry towards larger vessels. Despite concerns by 7 of 10 operators over the size of the industry, 4 companies suggested that they were likely to add a new boat or upgrade an existing one to a larger vessel in the near future. Seven companies suggested that more specific training and education for skippers and guides would be valuable to the industry.

1. 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 sparsely populated. However, human impacts along this coast are extensive due to environmental modification associated with diamond mining, fishing, and coastal development. The majority of marine research in Namibia since independence has focussed on fisheries. Research on marine top predators has been limited to birds and seals with almost nothing known about the cetacean (whales and dolphins) community.

The Namibian Dolphin Project (NDP) is a conservation and research project studying whales and dolphins in Namibian waters. The project began in 2008 with a pilot study in Walvis Bay supported by the Namibia Nature Foundation and funded by the Rufford Small Grants Society and the British Ecological Society. The pilot study was regarded as highly successful and the project has subsequently been expanded to a secondary field site in Lüderitz with data being collected in both summer and winter months. The principal goals of the NDP are to:

1) Assess the conservation status and health of dolphin populations in Namibia
2) Assess potential threats to these populations (especially marine-ecotourism and coastal development).
3) Collate information on species composition of cetaceans in Namibian waters through at sea observations, collation of records of stranded animals and attendance at strandings where possible.
4) Train locally based conservationists to respond to live and dead stranded cetaceans for rescue and data collection purposes.
5) Research the ecological interactions of whale and dolphin populations through collection of data on habitat use, behaviour, diet, population structure and abundance
6) Work with local scientists, conservationists and the tourism industry to provide training and feedback to increase knowledge levels about Namibian cetaceans and conservation concerns
7) Provide information to and work with the government (MFMR, MET) and local NGOs (CETN, NACOMA, NNF) to help manage threats to the populations
8) Work with the local marine ecotourism industry (MTAN) in Walvis Bay to help develop best practise habits that will ensure long term sustainability of the industry
9) Publish results in the scientific and public media

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 and dusky 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 kilometres 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 and 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 has been reported to range 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 in southern Angola. 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 are several human activities along the Namibian coastline with the potential to disrupt dolphin behaviour and affect the long term health of the population, these include: harassment by boats, particularly those associated with the large marine tourism industry in Walvis Bay, aquaculture, especially the interaction between bottlenose dolphins and oyster farming in Walvis Bay, coastal development, especially port expansion activities within Walvis Bay and coastal mining. We address each of these separately below.

Boat activity

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 (Corkeron 1995, Janik and Thompson 1996, Van Parijs and Corkeron 2001, Williams et al. 2002, Bejder et al. 2006). 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 and Higham 2004). 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 or disturbance within them could have important population level impacts for dolphins by changing the type or reducing the amount of food available.

Aquaculture

The effects of aquaculture on cetaceans are not well studied and may differ between netted cages (fin fish farms) and the open lines used for growing bivalves such as oysters and mussels. Effects may be obvious such as entanglements in the anti-predator nets or lines resulting in injury or death (Diaz-Lopez and Bernal-Shirai 2007). Other effects may be much subtler and harder to measure, such as habitat loss. 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 (Markowitz et al. 2004). In some cases, aquaculture farms have resulted in apparently positive effects for marine mammals. Nutrient shedding and the creation of artificial reefs may 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 et al. 2003). A positive association between dolphins and aquaculture has only been demonstrated in the relatively nutrient poor Mediterranean Sea. Indications from Walvis Bay suggest that bottlenose dolphins occasionally have a positive association with the aquaculture farms, particularly within summer months when nutrients within the bay are lower. Thus, in its present state and size, this industry does not appear to detrimentally affect this population. However, long term monitoring of this dynamic industry is essential, as the number and locations of farms is changed frequently due to mass deaths associated with sulphur blooms and red tide events.

Coastal development - Port expansion

NamPort, the Namibian port management authority, is in the process of expanding the Walvis Bay harbour by building an extension to the container terminal. This expansion is 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. The NDP has registered as an Interested party for this project 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 (Richardson et al. 1986, Ketten et al. 1993, Richardson et al. 1995, Todd et al. 1996, Barlow and Gisiner 2006).

Figure 1 – 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

Coastal mining

Coastal diamond mining in Namibia has been taking place for over 100 years. This type of mining involves reclaiming the sea bed as far as possible out to sea by building seawalls to hold back the ocean, and removing the sediment to bedrock level to search for diamonds. This type of mining is restricted to the southern part of the Namibian coast between the Orange River and Elizabeth Bay. Nearshore benthic fauna in this sandy environment are killed, removed or buried in the process of building and removing seawalls. Both Heaviside's dolphins and bottlenose dolphin are known to feed nearshore (<2km) in Namibian waters. Although Sandwich Harbour was previously regarded as the southern range limit of this population of animals, a recent finding of this study suggest that these animals range at least as far as Lüderitz Bay, and thus may transit through areas affected by these mining activities.

Near shore mining may affect dolphins through increased noise and sediment pollution and decreased food availability due to reclaimed land. No published data are available on the fine scale distribution patterns, behaviour or ecological interactions of Heaviside's dolphins between Lamberts Bay, South Africa (Elwen et al. 2009) and Lüderitz, Namibia (this study). The real impacts of mining on coastal cetaceans is currently unknown but further study is certainly needed.

2. Report findings

This report includes data from a wide variety of sources and methods. Each section will be presented independently with a brief introduction, methodological approach, results and a brief discussion of findings. Due to the focus of NDP staff on processing data for publication in the last year, there is an imbalance in the relative results from different aspects of the project as some are published or ready to submit while others are still ongoing. Submitted and published papers are attached as appendices to the report, summaries of the results will be presented in text.

Please consider all results presented in this report as preliminary and do not cite without permission of the authors

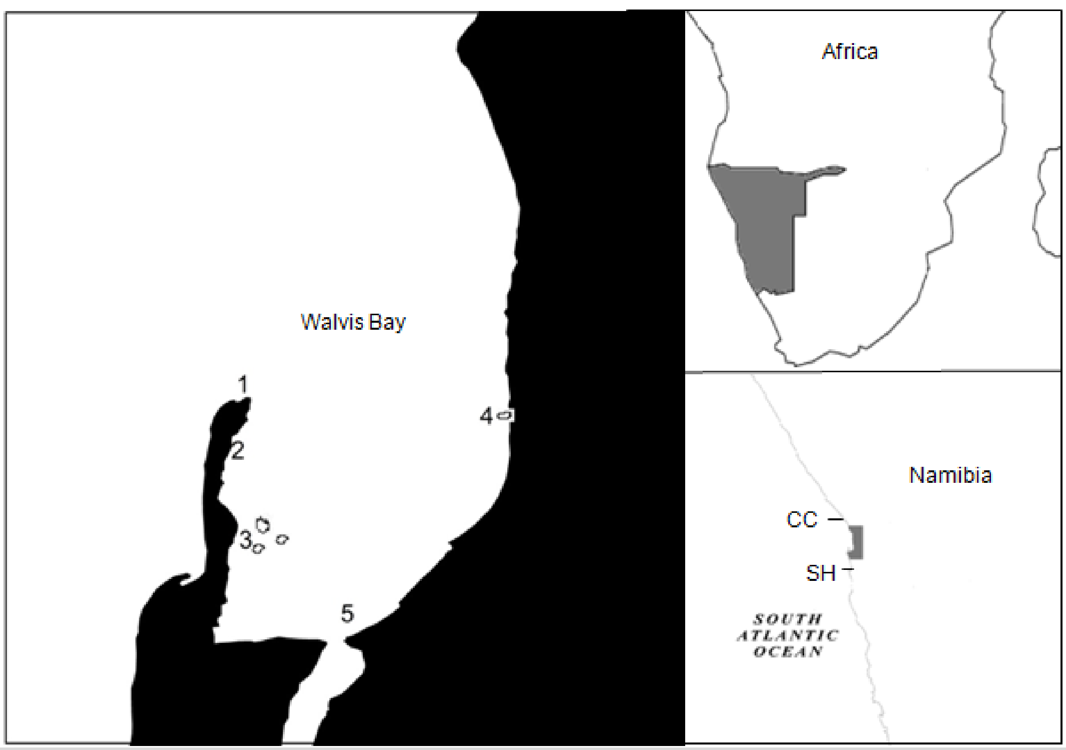


Figure 2. Location of the study area on the west coast of Africa (1 = Pelican Point, 2 = Seal Colonies, 3 = Oyster farms, 4 = Bird Island, 5 = Yacht Club, SH = Sandwich Harbour, CC = Cape Cross).

2.1 Field work - Boat and land surveys

Introduction and Goals

This aspect of the project is the core of the Namibian Dolphin Project and consists of boat and land based surveys in Walvis Bay (WB) and Lüderitz (LDZ). Surveys collect data on the location, size, composition and behaviour of all groups of dolphins and whales encountered. Photographic identification is a core research method and allows us to identify individual animals and over time study their movement habits, interactions, behaviour and most importantly abundance. Here we present specific methods and results (days at sea etc.) for the 2010 field seasons but include summary results from all seasons since 2008 in our analyses.

Principal goals of this aspect of the NDP are:

1) Seasonal and total abundance and residence patterns of bottlenose (WB) and Heaviside's dolphins (WB and LDZ)
2) Habitat use patterns of bottlenose and Heaviside's dolphins within Walvis Bay – investigating environmental and human influences and possible management strategies.
3) Behavioural habitat use of bottlenose dolphins in WB – investigating optimal locations for a protected area with reduced tour boat activity
4) Investigate seasonal and spatial variation in diet and population structure of bottlenose and Heaviside's dolphins using fatty acids and stable isotopes
5) Investigate broadscale population linkages of humpback and southern right whales in collaboration with dedicated studies in other parts of the region using photo ID and genetic techniques
6) Investigation of leatherback turtle habitat use and abundance in WB

Methods – Boat surveys

Boat based surveys were conducted in the winter and summer months of 2008 (WB only), 2009 (WB only) and 2010 (WB & LDZ) using a 6m rigid inflatable boat with twin 50HP 2-stroke engines. In WB, Surveys were performed on approximately alternate days in an effort to spread search effort out over the field season. Survey tracks were random within the bay and surrounding coastal waters, but due to concurrent work on Heaviside's dolphins (*Cephalorhynchus heavisidii*), search effort was biased towards Pelican Point (Figure 2). Boat based photo ID (winter only) and biopsy collection (summer and winter) surveys were run in Lüderitz during 2010. Search effort was focussed on Guano and Shearwater Bays, where Heaviside's abundance is known to be high.

In both locations, the focus of the study was to maximise encounters with the animals to estimate abundance rather than to conduct unbiased surveys for investigation of habitat use. In WB, radio contact with tour boats frequently alerted the research vessel to the location of turtles, dolphins and whales within the bay and greatly increased our encounter rate.

Once a group of animals was sighted they were approached slowly so as to minimise disturbance and both sides of the dorsal fin of each individual was photographed if possible. For southern right whales, photos of the callosity patterns on the head were taken and for leatherback turtles, photos of the pineal spot on the top of the head if possible. For each group of animals, the GPS location, group dispersion (bunched, dispersed or sub-groups), and number of tour boats present throughout the encounter were also recorded. An effort was made to avoid tour boats wherever possible by working with the animals either before or after tour boats had viewed the group. The location of the research vessel was recorded every minute using a Garmin eTrex GPS. Tracks from this GPS were used to analyse spatial variation in search effort, and dolphin distribution in ArcGIS 9.0 (ESRI)

For all groups of animals behaviour was recorded at the beginning and end of encounters and if it changed during encounters. For bottlenose dolphins, focal behavioural follows have taken place since 2009. Once photo-ID was regarded as complete by the photographer, the boat moved slightly away (at least 50m) from the animals to minimize impact on their behaviour and the dolphins were then followed for up to 3 hours (mean 1h 44 min ± SD 55 min). Group behaviour was recorded every three minutes (to allow for fine scale analysis and later sub-sampling if needed) based on what more than 50% of the group was doing. Behaviours recorded were 1) travelling 2) milling 3) resting 4) diving 5) socialising 6) surface feeding and 7) submerged/unidentified. Behavioural descriptions were modified from Lusseau (2003) and designed to be independently distinct but describe the full repertoire of behaviours performed. See Snyman et al. (in review; Appendix 5) for full description.

Land surveys – dolphins and birds

In the winter of 2010 land based surveys were conducted from three sites at points along the east coast of Walvis Bay between the Bird Island and Dolphin Beach (Figure 2). The principal goal of shore based observations was to collect information on bottlenose dolphin behaviour without the potentially biasing impact of recording from a boat and to provide visual comparison to the acoustic recordings made by the C-POD at Aphrodite Beach. A secondary goal was to investigate temporal patterns of attendance by birds on the beach and their disturbance by people and cars.

A minimum of an hour was spent at each site, with effort biased towards the morning due to frequently strong winds in the afternoons. Two or three observers constantly scanned the water with naked eye and binoculars. At five minute intervals, all beach users (cars, people) and sea users (boats, kayaks) were recorded along with counts of all the most frequently seen species of bird. If bottlenose dolphins were sighted, behavioural observations and tracking commenced. Behaviour was collected as above and locations were recorded as frequently as possible by noting the GPS position of the observer when immediately parallel to the animals and estimating their distance offshore. Distance estimation trials using a boat moving offshore from the observer were performed prior to data collection to train observers. If close enough to shore, the animals were photographed for identification purposes. The low lying nature of the coastline prohibited the use of a theodolite for tracking animals more precisely.

Insufficient data are available at this stage for the analysis of bird sightings, however dolphin sightings and photo-ID images have been included in analyses below.

Results

In total, 82 days (nearly 370 hours) were spent at sea in Namibia by the NDP team in 2010 and 19 days on land surveys in Walvis Bay.

2.2. Heaviside's dolphins

During 2010, bottlenose dolphins have been given a higher priority than Heaviside's dolphins due to conservation concerns raised by the NDP in 2008 and 2009. Thus, not all Heaviside's dolphin data have been processed. Photo grading (an essential part of photo-ID studies) has been completed for the entire data set between 2008 and 2010. Identification of individual dolphins is only complete until the end of 2009 and is ongoing. Although a considerable number of new animals have been identified using the Walvis Bay area since 2008, several animals initially identified in 2008 have been resighted subsequently (n= <10 based on a very preliminary assessment of the catalogue) supporting earlier findings from South Africa that individuals of this species show site fidelity to small areas tens of kilometres along shore.

Location	Season	Days at Sea	Survey hours:min	Photos	Heaviside's dolphin	Bottlenose dolphin	Dusky dolphin	Humpback whale	Right whale
Walvis Bay & Sandwich Harbour	summer	32	159:46:00	4429	30	22	0	9	0
	winter	35	152:46:00	10271	30	18	0	0	0
	summer	6	22:39	447	6	0	0	0	0
Lüderitz	winter	9	34:33:00	3219	8	0	0	1	1
Total		82	369:44:00	18366	74	40	0	10	1

Table 1. Summary of time spent at sea in 2010 by the NDP and number of encounters with dolphins measures as days in which dolphins and whales were encountered in each season and location.

One of the animals first identified in Walvis Bay in 2008 (Catalogue number C-021) has been seen in each of the field seasons subsequently. On or close to the 11 Feb 2010, this animal was struck by the propeller of an outboard motor resulting in severe injuries to the left flank in the form of a series of deep cuts. The animal remained boat friendly despite its injuries and frequently approached to bowride the research vessel. Repeated resightings of this animal have allowed the monitoring of healing rate. Healing was rapid and extensive and the injuries were almost completely healed within 40 days of the initial sighting. The rapid rate of healing of dolphins may result in an underestimation in any visual assessments of injury to animals by for instance fishing lines, boat propellers or sharks. A full description of the injuries, healing and implications thereof can be found in Elwen & Leeney 2010 (Appendix 1)

Heaviside's distribution patterns have remained consistent since the 2008 field season, with the vast majority of sightings occurring within 2km of Pelican Point. Sightings away from Pelican Point in deeper water are more common in summer months than in winter months.

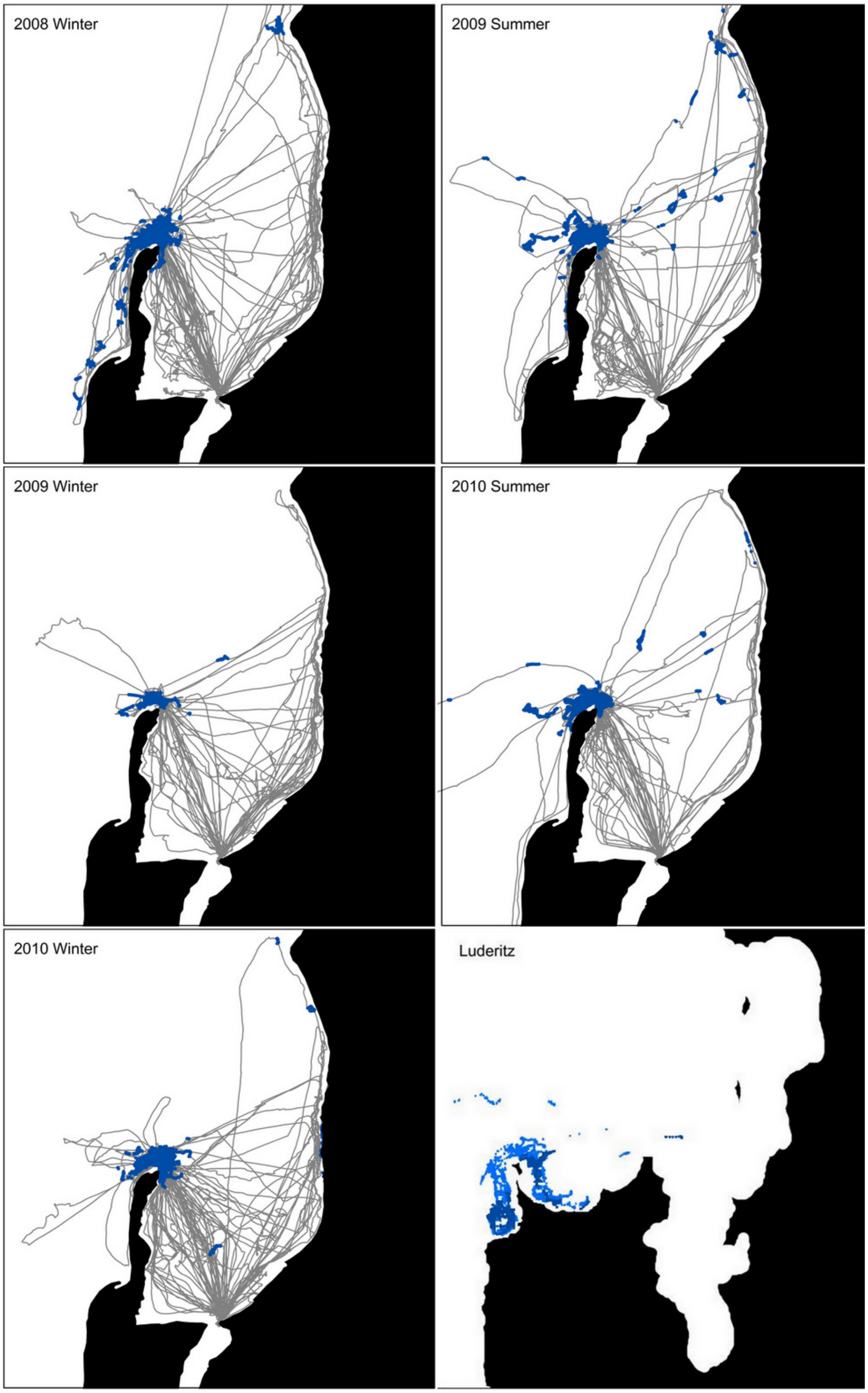


Figure 3. Distribution of Heaviside's dolphins (blue dots) and search effort (grey track lines of the research boat) in Walvis Bay for the five seasons worked by the Namibian Dolphin Project. Map in bottom right shows distribution of Heaviside's dolphins in Lüderitz for summer (dark blue) and winter (light blue) 2010.

2.3 Bottlenose dolphins

Temporal patterns and abundance

Variation in dolphin presence, group size, habitat use and behaviour has been considerable since the beginning of this project. This highlights the importance of long term monitoring to assess wild populations. The full sighting history of all known individual bottlenose dolphins is shown in a matrix format as appendix 5. In addition to sightings made from the research vessel, we have included two additional events of importance in this table: 1) the mass stranding event of 19 individuals up the Walvis Bay lagoon on the 19 March 2009 and 2) animals identified from shore based photographs taken by Dr Jessica Kemper in Lüderitz. Also shown is the known death of one animal (T-017 on 21 July 2010) and known mothers in the population.

Analysis of this sightings history matrix reveals several trends, many of which raise some concerns. More animals were identified in 2008 than in any other season, despite comparable survey effort in subsequent years. More animals are identified in winter seasons than in summer seasons (see also figure 4). Of the 70 animals identified in 2008, 19 (27%) have not been seen subsequently. From the beginning of 2009 onwards, 16 new adults or sub-adults have been identified and sighted multiple times subsequently. It is possible, although unlikely, that some of the animals not seen since 2008 have been misidentified as new animals due to the acquisition of new marks and scarring which are used for identification, however only seven of the 19 mentioned were regarded as ‘poorly marked’ in 2008, the remainder were easily identified. The animals identified as mothers in 2008 were seen regularly during this season, but have only rarely been seen since, suggesting they no longer use the bay as a principal habitat. Not all animals are seen with a similar frequency, which leads to misinterpretation when only ‘number of encounters’ (rather than identifications) is used to infer dolphin presence in the bay. A small group (designated ‘Grp1’ in the table), consisting of mainly younger animals (smaller size, paler skin colour), are frequently seen together and make up the majority of encounters in Walvis Bay, both with the research vessel and the tour boats. Frequent encounters with a small number of animals can create a false sense of perceived abundance which can hamper conservation efforts.

Two new calves have been born since 2008, to mothers T-022 and T-046 (sightings histories not shown). However, 2 calves are known to have died and 4 adults (2 definite, 2 unconfirmed reports) are known to have died. The disparity in these numbers, combined with an apparent 'loss' of 19 animals from the Walvis Bay population and reduced sightings of many others is of concern. A full analysis of the abundance of the population has not been done since the pilot study. The number of individual bottlenose dolphins identified each season has reduced since the pilot study, with clear differences in the number of animals seen in the bay in the summer and winter field seasons (Figure 4). Analysing winter and summer trends separately shows a decline of 6-8% per year. A preliminary mark-recapture abundance estimate for each season shows a similar trend of decrease with lower estimates in summer (Figure 5, data from 2008 from previous analysis, 2009-2010 results are preliminary analyses). These estimates are calculated for the left and right side catalogues separately and take into account unmarked animals. Although the mark-recapture estimate does to some extent include animals

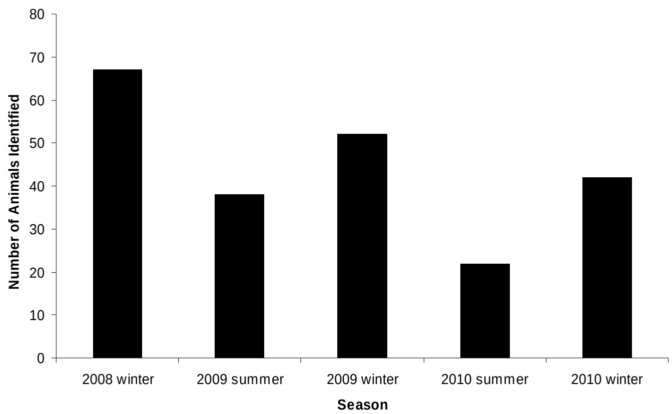


Figure 4. Number of bottlenose dolphins identified from dorsal fins (left & right side IDs combined) using Walvis Bay during field seasons of the Namibian Dolphin Project 2008 winter to 2010 winter.

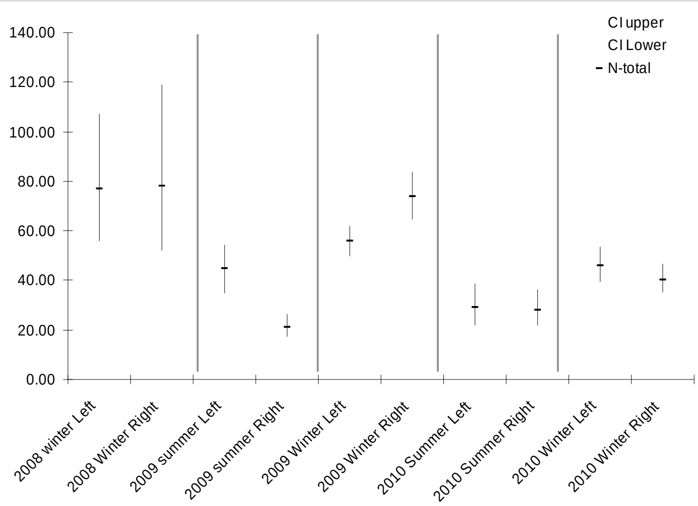


Figure 5. Mark-recapture abundance estimates of the number of bottlenose dolphins using Walvis Bay. Abundance was calculated separately for left and right side catalogues to create two semi-independent estimates for each of the 5 seasons. Figure shows total population size (controlled for number of unmarked animals) and upper and lower 95% confidence intervals. Seasons are separated by grey vertical line.

not seen (for example those outside the bay) it is affected by the number of animals encountered and effectively represents only the number of animals using Walvis Bay during the field season.

Together, these patterns of reduced sightings, lower number of individuals identified per season, low birth rate and high mortality are worrying. The results suggest that the population may be either decreasing in total numbers or not using Walvis Bay as frequently as in the past. Temporary and permanent emigration from an area impacted by tourism vessels has been observed in other locations (Lusseau 2005, Bejder et al. 2006). Although only one of several natural and human impacts on Walvis Bay including sulphur blooms, red tide events, prey variability, port activities and aquaculture, it is the high number and directed interactions of tour boats that are likely to be the most immediate threat to the bottlenose dolphin population. Reducing the (potential) impact of the tourism industry on the dolphin populations of Walvis Bay is one of the key goals of the NDP (see section 3 for a summary of the industry).

To this end, the NDP has been working with the industry towards developing a system of training and recognition for approved skippers, as well as aiding the MFMR in developing a new Code of Conduct for the industry as a precursor to developing a legal framework. Furthermore, we have used the data we have to investigate the potential for delineating a no-go zone or protected area in which boat access is limited, to provide a refuge area for dolphins within Walvis Bay. See further discussion below.

Spatial patterns and the possible delineation of a protected area

Survey effort was wide ranging over the entire bay and surrounding coastline (Figure 6). Walvis Bay was divided into sectors to investigate broadscale distribution patterns within the bay and divided to reflect 1) the Pelican Point area 2) the open east coast area 3) the harbour area and 4) the oyster farm area.

Some clear distribution patterns are immediately obvious: the Pelican Point and east coast areas were used in all seasons, whilst the mid bay area was rarely used. Distribution patterns appear to be more clustered in the summer months than in winter months. Dolphins were never encountered (or followed) into deep water when outside the protected environment of the bay. When observed along the exposed coastlines to the north and south of the bay, dolphins remained very close to shore, usually within the backline of the surf zone. However, when all seasons were combined (Figure 6) it is clear that bottlenose dolphins use the majority of the bay over the longer term.

Probability density kernels (or utilization distributions UD) were used to investigate areas of consistently high use. These were calculated using the start locations of encounters of groups of dolphins clearly show consistent use of the Pelican Point and east coast region in all seasons.

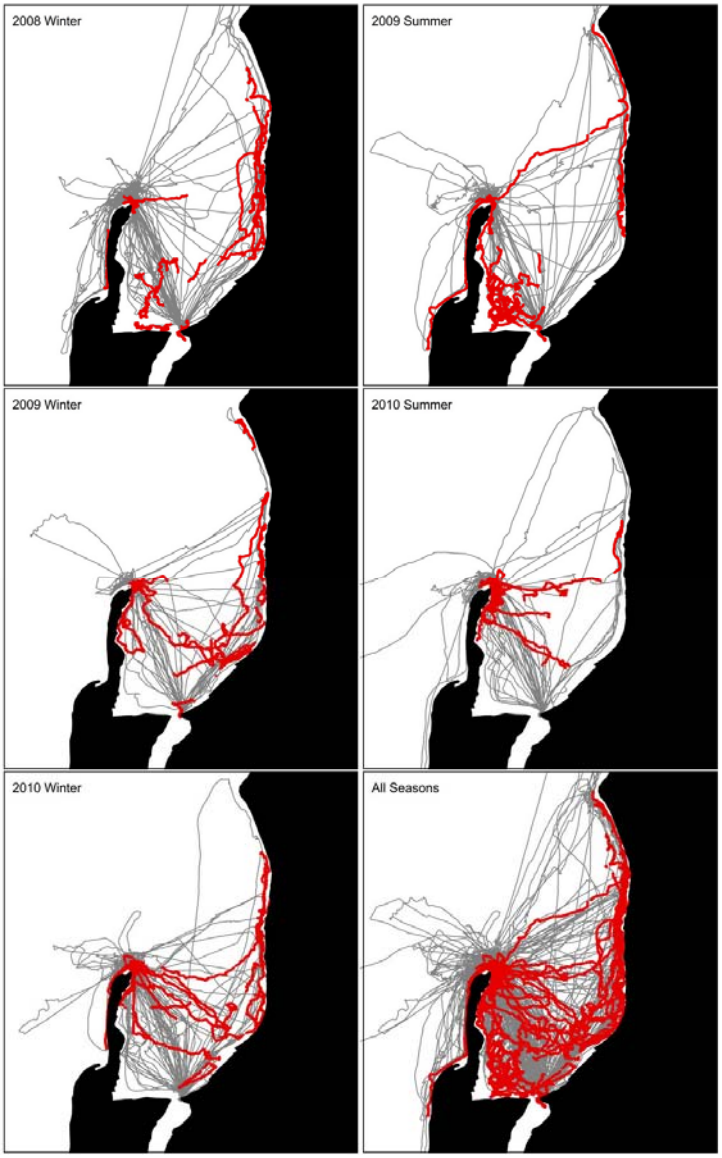


Figure 6. Series of maps showing survey effort (grey lines) and bottlenose dolphin encounters (red dots) during 5 seasons of field effort in Walvis Bay, Namibia, including all effort combined (bottom right figure). Number in top left of each map indicate the percentage of encounter time spent in each section of the map, marked as 1-4 on maps.

Habitat use patterns measured simply as 'encounters' do not account for individual differences and may be biased by frequent sightings of only a few individuals. We investigate habitat use at the individual level by calculating the number of individuals using different parts of the bay using a fine scale 2x2km grid (Figure 7). In all seasons, grid squares along the north east sector were consistently used by a high proportion of individuals (Figure 7). This pattern was particularly clear when all seasons were combined, with more than 80% of identified individuals seen here at some point, including all known mothers (Figure 7). Seasonal differences are apparent in the use of the Pelican Point area and west side of the bay (near the oyster farms) with a higher proportion of animals using these areas in summer than winter. A considerable number of surface feeding events were observed in this part of the bay (Figure 8), especially in summer (data not shown by season). The low proportion of individuals observed in the extreme north and south, and the high proportion seen at Pelican Point likely reflect the relatively low search effort in those regions.

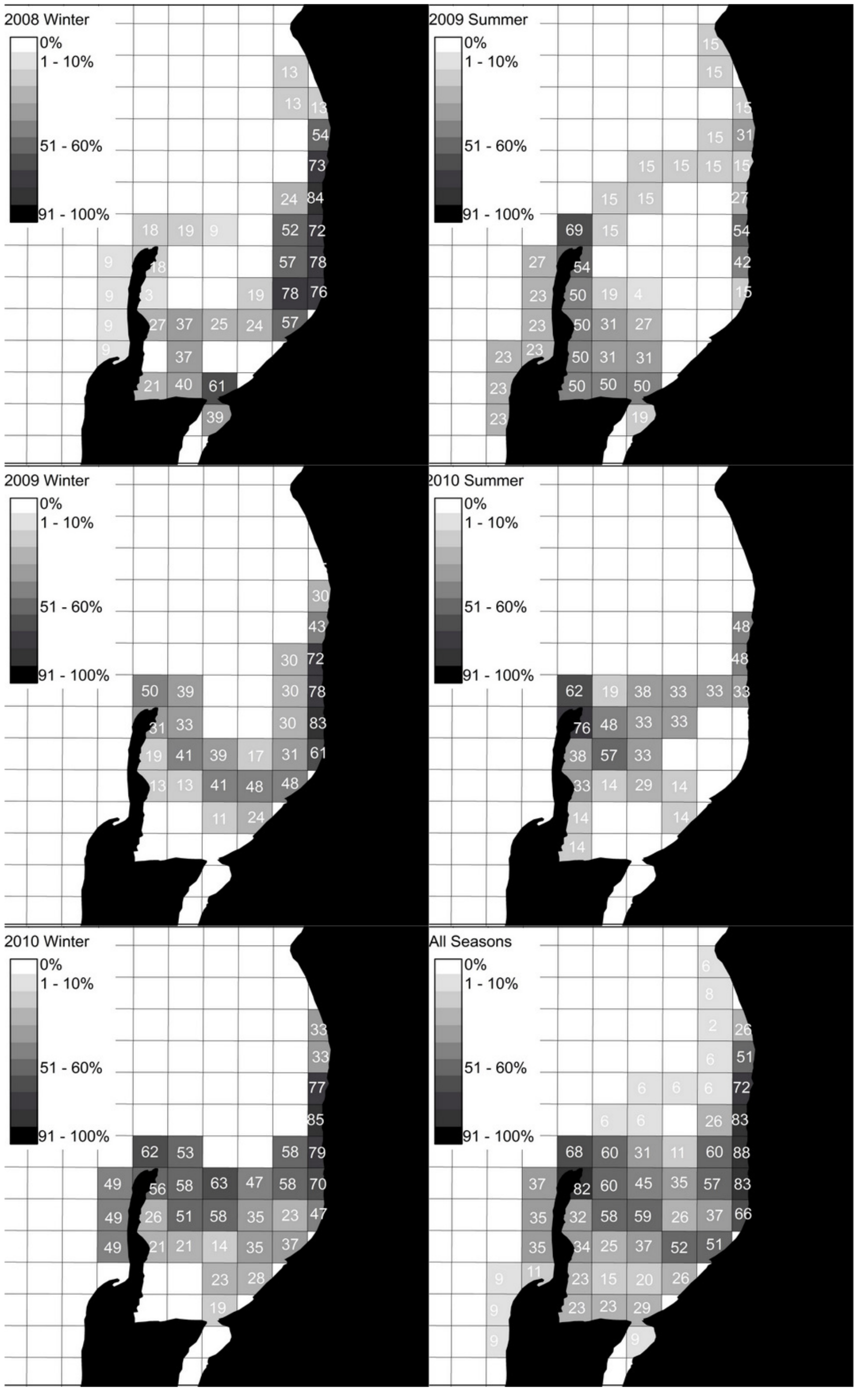


Figure 7. Percentage of individual bottlenose dolphins using 2x2km grid squares in Walvis Bay, Namibia. Percentages calculated from the total number of individuals identified in each season (see figure 4).

Once key habitats are identified based on their frequency of use, it is important to identify their function. Our spatial analysis of bottlenose dolphin behaviour has illustrated clear patterns. Walvis Bay was not used in a in a uniform manner by dolphins (Figure 8). Socialising is one of the most frequently observed behaviours in this population and occurred throughout the bay. Surface feeding was observed most frequently at Pelican Point and in the south western part of the bay. Resting behaviour was predominantly observed along the east coast. Although a formal analysis has not yet been carried out, bottlenose dolphins in Walvis Bay have been observed to socialize regularly in the presence of tour boats, while resting animals are easily disturbed by boats. Resting forms an integral part of an animal's activity budget allowing it time to recuperate. As such, resting is regarding as the most sensitive and important behaviour.

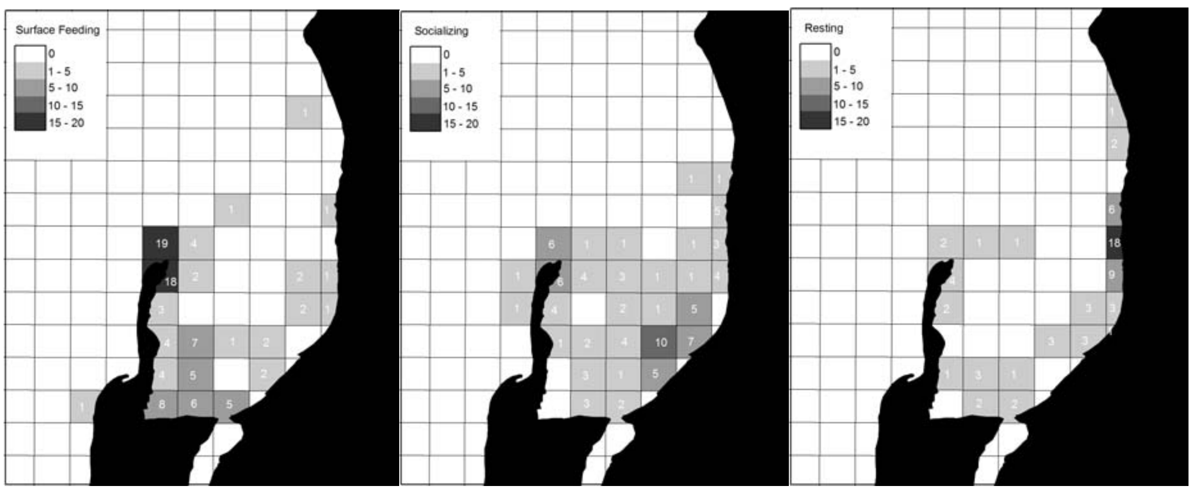


Figure 8. Series of maps showing distribution of the observed frequency of 3 key behaviours in Walvis Bay, Namibia. Data collected between 2009 (summer) and 2010 (winter) all combined. Numbers within 2x2km grid squares are frequency of observations taken at 15min intervals (subsampled from original data to reduce autocorrelation).

When all spatial and behavioural data were considered two main areas of usage appeared (Pelican Point and the east coast area). However, taking into consideration the reliance of tour operators on the Pelican Point area to provide wildlife sightings, and the high level of shipping traffic passing close to this area in transit to or from the Walvis Bay port, the coastal zone north of Bird Island on the eastern side of the bay offers more viable potential for delineation as a protected area. Designation of this area would provide an undisturbed location for energetically important resting behaviours, and introduction of boating restrictions here would be relatively less disruptive to the local community, since vessel utilization of this area is already infrequent (Figure 9).

A selection of 16 GPS tracks recorded from 5 tour boat operators is presented in Figure 10. The majority of these tracks were recorded in the winters of 2008 and 2010, but reflect a fairly typical route for boats operating in Walvis Bay. All boats launch in the south east corner of the bay, at the Walvis Bay Yacht Club and although routes vary the majority of tours take in a series of standard attractions and places of interest including observing pelicans (usually near the yacht club), an oyster farm (western side of the bay), a seal colony and Heaviside's dolphins at Pelican Point and the Bird Island on the east side of the bay (Figure 10). Other wildlife, including sunfish (*Mola mola*), leatherback turtles (*Dermochelys coriacea*), humpback whales (*Megaptera novaeangliae*), southern right whales (*Eubalaena australis*) and bottlenose dolphins, are less predictable in their distribution (and in some cases more seasonal) and are approached wherever they are encountered. Radio communication between vessels greatly increasing the probability of finding animals and consequently the number of boats encountering them. Tour boats also interact closely with pelicans (*Pelecanus onocrotalus*), cormorants (*Phalacrocorax capensis)*, skuas (*Stercorarius parasiticus*) and Hartlaub's gulls (*Chroicocephalus hartlaubii*).

Figure 9. Map showing a series of X typical tracks recorded from multiple tour boats (and companies) recorded during the winter seasons of 2008 and 2010. Proposed protected area shown as black rectangles.

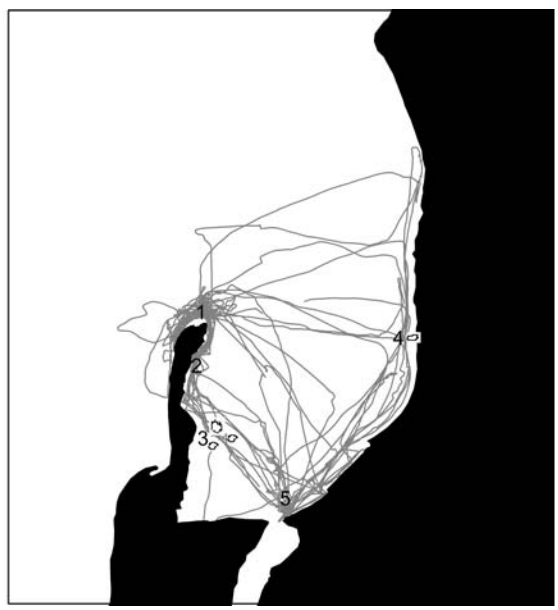


Figure 10. A set of typical tour boat tracks collected over from different tour boats collected over 16 days during the survey season winter 2008 and winter 2010. 1 = Pelican point, 2 = the seal colonies, 3 = the oyster farms, 4 = bird island, 5 = yacht club.

Due to fuel costs and distance, searches up the east coast by tour boats, in the absence of confirmed groups of animals, rarely extend north of Bird Island. However, whales and bottlenose dolphins will be followed up this coast past Long Beach if encountered. Unfortunately, several of the tour boat trip tracks displayed in Figure 10 were influenced by the sightings made by the research team doing shore based observations here during the winter of 2010, thus falsely increasing the number of 'actual' trips to this area. The proposed no-go zone thus represents a very small fraction of the area which tour boats use on a regular basis and affects only one of the species looked at by tour operators,thus it is highly unlikely to negatively influence the activities of the tourism industry which comprises an important source of income for the Walvis Bay area.

2.4 Static Acoustic Monitoring

Since August 2009, the NDP and MFMR have been investigating the long term acoustic behaviour and attendance patterns of dolphins at several key sites along the Namibian coastline using passive acoustic monitoring. The two main study areas are at Pelican Point and Aphrodite Beach (in Walvis Bay) and at Shearwater Bay and Diaz Point (in Lüderitz). The C-POD at Aphrodite beach is situated in the known resting area used frequently by bottlenose dolphins, all other sites target Heaviside's dolphins. Six C-PODs (www.chelonia.co.uk) have been deployed and they are serviced at 3-4 month intervals. An initial deployment in Guano Bay, Lüderitz was unfortunately lost in bad weather resulting in a loss of several months of data. Since 2010, short term deployments have been made at Sandwich Harbour, a non-impacted pristine nature reserve area approximately 50km south of Walvis Bay. This area provides a control site in which human presence or influence on dolphins is effectively zero. Due to the isolation of the area and difficulty of servicing the instruments, the Sandwich Harbour C-POD is only deployed during field seasons when boat surveys are being run by NDP staff.

Results

Total deployment times for all C-PODs are presented in table 2 below. Only preliminary analyses have been performed to investigate broad patterns in the data. Full analysis will be run once two whole years of data are available to account for seasonal variation in behaviour.

Site	Deployment period(s)	Total POD hrs at site	Total Days
Pelican Point (WB)	13/08/2009 – 25/11/2010*	16241.7 **	676.73**
Aphrodite Beach (WB)	20/08/2009 – 25/11/2010*	10939.3	455.8
Shearwater Bay (LDZ)	23/08/2009 – 19/11/2010*	10802.4	450.1
Diaz point (LDZ)	31/03/2010 – 19/11/2010*	5526.6	230.3
Sandwich Harbour	24/02/2010 – 06/03/2010 12/06/2010 – 13/08/2010	1717.8	71.6

Table 2. C-POD data summary as of January 2011. 'Deployment period' indicates the general period over which there has been almost-continuous monitoring. Because C-PODs have to be retrieved for data download and battery replacement every 3-4 months, there are gaps in the data of one to several days, at 3-4 month intervals throughout these periods.

*C-PODs at these sites have been re-deployed in November 2010, thus monitoring is ongoing.

** 2 C-PODs were deployed at this site for 8 months near the surface and sea floor respectively, so ~200 days of this recording time represents simultaneous recordings of these two instruments

Ecological interactions

Preliminary analysis of detection patterns from the initial deployment periods are presented in Figure 10 and 11. Of note is the strikingly different diel attendance patterns of Heaviside’s dolphins at the concentration sites at Pelican Point in Walvis Bay (Figure 10) and at Shearwater Bay in Lüderitz (Figure 11). In Walvis Bay, it is evident that Heaviside’s dolphins are detected more frequently during the night than during the day, while in Lüderitz the pattern is the opposite (more detections by day, than by night), which is similar to patterns observed using other survey methods in a previous study of in South Africa. Observations made from shore (Elwen et al. 2009) and using satellite telemetry (Elwen et al. 2006) showed that Heaviside's dolphins in South Africa to be closest to shore during the mornings, between 06:00 and 12:00, and furthest from shore (up to 20km) at night. The clear diel onshore-offshore migration pattern observed in South Africa is thought to be associated with feeding nocturnally on vertically migrating demersal prey, most likely juvenile shallow water hake, *Merluccius capensis* (Sekiguchi et al. 1992, Elwen et al. 2010). During previous studies in South Africa, Heaviside’s dolphins have never been observed to exhibit clear feeding behaviour and when inshore, and are thought to be primarily resting or socialising. In both Walvis Bay and in Lüderitz, feeding behaviour has been clearly observed, in the form of association with feeding birds (Cape gannets) and fish in the mouth of a dolphin (Figure 12). Although our results are only preliminary, these striking patterns and observations strongly suggest that Heaviside’s dolphins in Namibia and in particular in Walvis Bay are likely to be eating different prey (or prey with different diurnal movement habits) than in the southern Benguela. Considerable further work is needed to understand the different ecological interactions occurring throughout the range of the species. Investigation of seasonal and sparial variation in diet is currently underway using stable isotopes and fatty acids

Assessment of human impacts

Figure 13 shows visual counts of tour boats present at at Pelican Point, in Walvis Bay. These counts were made from the research vessel when it was in the Pelican Point area and reflect the total number of boats in this ~2x2km region. Counts of boats show that up to 14 boats could be present in the Pelican Point are at one time interacting with Heaviside's dolphins. However (comparing Fig 10 and Fig 13, although note different time scales), the duration of this impact period is relatively short (2.5-3.5hrs) given the continual use of the area by Heaviside’s dolphins. Direct interactions between boat presence and dolphin behaviour have not yet been analysed.

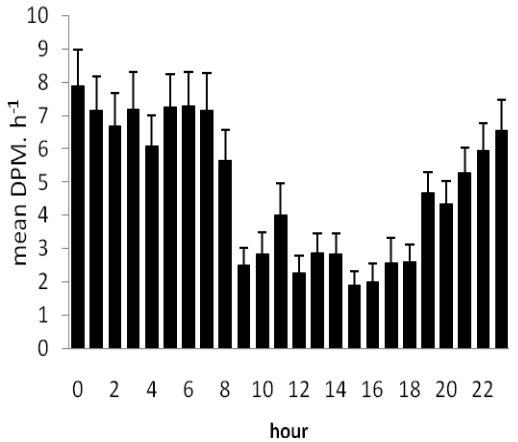


Figure 10. Diel pattern of Heaviside's dolphin attendance at Pelican Point, Walvis Bay as detected using a clicking rates between Sept – Dec 2009. Detections (y-axis) measured as mean 'detection positive minutes' in each hour of the day from midnight. Note lower detections between ~08:00 and 18:00.

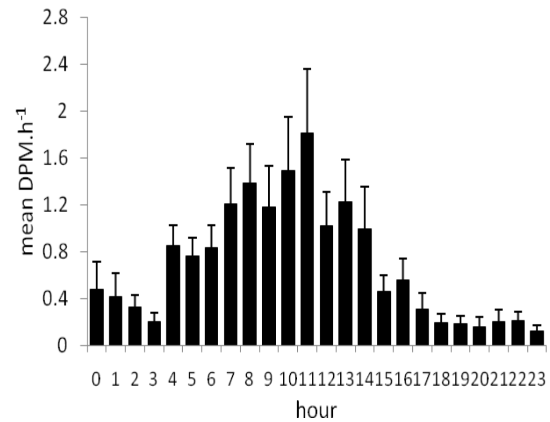


Figure 11. Diel pattern of Heaviside's dolphin attendance at Shearwater Bay, Luderitz as detected using a clicking rates between Aug – Dec 2009. Detections (y-axis) measured as mean 'detection positive minutes' in each hour of the day from midnight. Note lower detections between ~08:00 and 18:00.

Figure 12. Photograph of a Heaviside's dolphin with a fish in it's mouth showing clear feeding behaviour at this site. Feeding behaviour has never been observed nearshore in the southern Benguela (see text for details)

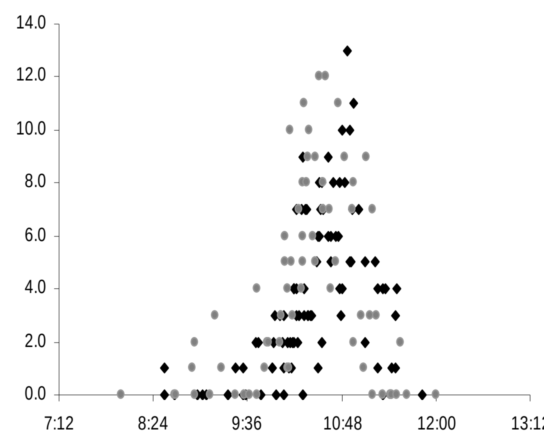
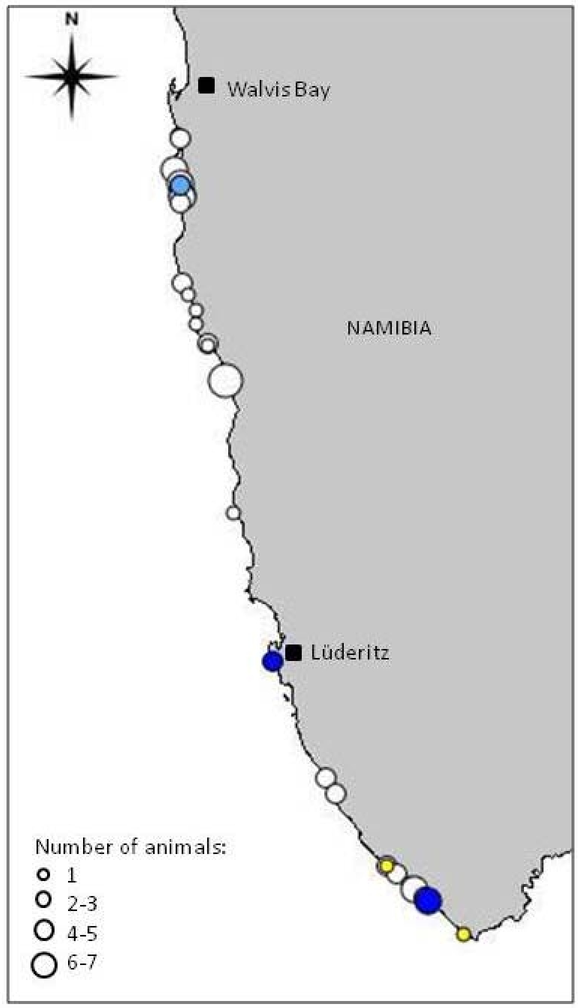


Figure 13. Instantaneous counts of all tour boats observed at Pelican Point by the research vessel during 2008 (black dots) and 2010 winter (grey dots). Tour boats are present at Pelican Point mainly between 8:00am and 12:00 with a peak between 10:30 and 11:00am

2.5 Results – Aerial Survey

On the 29 November 2010, the NDP ran it's first aerial survey with assistance from the *Bateleurs* group (http://www.bateleurs.co.za/2010-Missions/namibian-coastal-survey.html). The goals of the survey were to assess the distribution of Heaviside's and bottlenose dolphins at a much broader scale along the Namibian coast than we had previously been able to, as well record the presence of other species of whale, dolphin and turtle and photograph them if possible.

A single survey was run with a search height at 300ft. This height was a felt to be the best compromise between seeing a larger area (higher is better) and being able to spot small dolphins (lower is better). The survey route ran south from Walvis Bay to the Orange River with one refuelling stop at Lüderitz airport.The survey route tracked the coast at a distance of approximately 100 m from the shore.



Sightings of Heaviside's dolphin (white circles), dusky dolphin (light blue), Southern right whale (dark blue) and sunfish (yellow) on the aerial survey from Walvis Bay to Oranjemund, 29 November 2010.

In total, 63 Heaviside's dolphins, two dusky dolphins and six southern right whales including a mother-calf pair were sighted. Heaviside's dolphins were most common along the coast between WB and St Francis Bay (25.07° S) and towards the south of the survey limit. All southern right whales were seen south of Lüderitz supporting previous aerial survey results reported by Dr Jean Paul Roux (MFMR).

3. Tourism Industry Assessment

The NDP assessed the size and value of the Walvis Bay marine tourism industry in 2008 and again in 2010. Here we present the results from 2010. Data were collected using a one-on-one interview approach by one interviewer (R. Leeney) with company managers/directors/owners . Data were collected on ticket prices, number of passengers, boats, crew, permanent and part time staff. Results are presented for separately for companies operating motorised and sail powered vessels and companies operating kayak tours.

Comparison between 2008 and 2010

In 2008, interviews were first carried out with the 8 companies (including 2 kayaking operators) running marine tours in Walvis Bay. The follow-up interviews in 2010 provide an opportunity to examine how the marine wildlife-watching tourism (MWWT) industry has developed in Walvis Bay over a two and a half year period.

The total number of companies is now 7 companies running motor boat or motor/sailing cruises and 3 companies running kayaking trips. The number of motorised vessels operating in the bay has increased from 25 (21 ski boats and 4 sailing catamarans) up to 27 (14 smaller ski boats, 6 large sailing catamarans and 7 large ski boats/motor catamarans). At least two of the smaller ski boats used in 2008 have retired or been partially retired, while there has been a move to larger motorised catamarans which can hold more passengers.

Ski boat — Motorised Catamaran — Sailing Catamaran

Fig 14. Showing three different types of tour boat operating in Walvis Bay, Namibia

Future of the industry

When asked about business plans for the next 12 months, 4 companies suggested that they were considering adding another boat to their fleet or replacing an older boat with a new, larger vessel. 2 companies are changing ownership or have done so in the last 6 months. This suggests that the industry is attracting new people to the area but also that these people may not be familiar with the area, the wildlife or with the history of the MWWT industry in Walvis Bay.

Summary of concerns expressed by the Industry:

- Harbour development was seen by some but not all company owners as potentially detrimental to the area and/or its wildlife.
- The growth of the industry or number of boats currently operating in Walvis Bay was mentioned by 7 operators (including 2 kayaking companies) as a concern for the area and the industry.
- Many interviewees (7 companies) suggested that more education or training specific to that part of the industry operating motorised vessels in Walvis Bay would benefit the industry as a whole.
- Also mentioned were aspects such as the driving behaviour of some skippers and the time spent by some boats with dolphins or whales (too long), changes in water temperature affecting the local wildlife, exploration for oil and gas off the Namibian coast and its potential effects on cetaceans.
- One operator was concerned about the ‘no-go zone’ (discussed and proposed in detail above, in Section 2.3, this was proposed to the industry by RL at the MTAN meeting on 24 Nov 2010). This operator regularly visits that area (Bird Island to Long Beach, along the coast) in Jan/Feb when the Point is quiet, as finding bottlenose dolphins there is quite reliable. He does not want the area to be closed as he feels it will affect his business.

4. Stranded Cetaceans

Stranded animals are highly valuable to the study of cetaceans as they provide a considerable amount of data on species which are often inaccessible. Some species of cetaceans (especially those which live in very deep water) are almost exclusively studied through access to stranded specimens. In a county such as Namibia where little is known about cetacean fauna stranded specimens are especially valuable. For example, in 2010 the NDP attended to a live-stranded dwarf sperm whale just south of Swakopmund. Although the rescue attempt failed (the animal died in transit) the event was noteworthy as this species has never been recorded in Namibian waters before (see Table 3 for other records occurring since 2008).

The NDP is not able to be in Namibia all year round but makes every effort to attend to stranded specimens of cetaceans and turtles when possible and to perform necropsies on those that can be kept frozen when not. The NDP has been working with various local groups to collate and collect information on stranded cetaceans including: the MFMR in Swakopmund and Lüderitz, the Desert Lion Project (Flip Stander – Skeleton Coast Park), the Walvis Bay Strandings Response Network (diverse members, see below), NACOMA (R. & J. Braby) and the general public.

The Walvis Bay area seems particularly prone to live strandings of cetaceans, possibly due to the shallow sloping nature of the beach within bay misleading animals. Many of these stranded specimens have been rescued over the years by various members of the public and the NDP has worked with the WB community to help develop the WBSN. The goal of the network is to formalise an existing loose network of interested parties in the WB area, to improve communication, increase skills and provide equipment for animal rescue and data collection.

Following up on a grant received from the Walvis Bay Municipality, the NDP generated a design for two dolphin stretchers, and had them made by a local supplier. These stretchers, along with several other items of strandings equipment purchased by the WBM grant (buckets, blankets, etc.) are now in the possession of the Walvis Bay Strandings Network, overseen by Naude Dreyer of Sandwich Harbour Tours. The NDP has also been liaising with WBM staff to develop information boards to erect at key sites around Walvis Bay. The boards will contain information on the marine life of the region (whales, dolphins and other species) as well as contact details for the WB Strandings Network, and will provide information for both tourists and the local community.

	Species	No.	Region	Condition (1-5)	Measures?	Samples collected?	Attended by	Notes
Unknown								
	Bottlenose dolphin	1	WB	5		skull	Elwen & Wearne	Long dead - collected in 2008
	Pilot whale	1	WB	5		skull	Collected by N. Dreyer	On show at Anchors coffee shop
	Pilot whale	1	WB	5		skull	Collected by N. Dreyer	On show at Anchors coffee shop
2008								
20080830	Pilot whale calf	1	SWK	2	?	?	MFMR & Rod Braby	Found stranded dead in high seas
2009								
20090214	Humpback whale	1	WB	1	yes	Multiple	Naude Dreyer et al when alive. Elwen et al when dead	Live stranded days before NDP field season started. Failed rescue attempt by WB locals
20090316	Bottlenose dolphin	19	WB	1	yes	Some	MFMR (Skrypzeck) & WBSN. Later Elwen/NDP	Some measures taken but in water, skin samples taken but later lost. 18 survived,smallest calf died
20091203	Dusky dolphin	1	WB	1	no	no	WBSN - J. Paterson	released alive
2010								
20100203	Heaviside's dolphin calf	1	WB	5	yes	Multiple	Elwen/NDP	
20100422	Bottlenose dolphin calf	1	SWK	2	yes	Multiple	Justine Braby / Dissection by Elwen/NDP	Lab dissection
20100613	Humpback whale	1	Swk	1	yes	Multiple	MFMR (Holtzhausen), R Braby, Paterson, Elwen/NDP	Live stranded - no chance of rescue - necropsy once dead
20100615	Dwarf sperm whale	1	SWK	1	yes	Multiple	Elwen/NDP	Alive, failed rescue attempt, full necropsy. New species record for Namibia
20100615	Humpback whale	1	C. Fria	2	yes	yes	F. Stander (Deser Lion Project)	
20100720	Humpback whale	1	Kunene	1	yes	yes	F. Stander (Deser Lion Project)	Alive, failed rescue attempt.
20100721	Bottlenose dolphin	1	SWK	2	yes	Multiple	Elwen/NDP	Known adult from catalogue
20100721	Humpback whale	1	WB	1	yes	Multiple	Elwen/NDP & WBSN	Alive, pushed from harbour but later died across bay
20100815	Bottlenose dolphin?	1	at sea	2	no	no	reported to MFMR (Holtzhausen)	In NATMIRC freezer awaiting dissection
20100824	Bottlenose dolphin?	1	SWK	2	no	no	Reported via Levo tours	not found
20100824	Pygmy sperm w.	1	LDZ	2	yes	Multiple	MFMR (Roux) & NDP/Elwen	Freshly dead - rapid beach necropsy
20100826	Pygmy sperm w.	1		1	yes	Multiple	MFMR (Roux) & NDP/Elwen	Failed rescue attempt, necropsy once dead
20100915	Heaviside's dolphin calf	1	WB	2	no	no	WBSN/Naude Dreyer	In NATMIRC freezer awaiting dissection

Table 3. Summary of stranded cetaceans attended or collated by the NDP. (WBSN = Walvis Bay Strandings Network). Condition = (1) Alive, (2) Fresh dead, (3) Slightly decomposed, (4) very decomposed, (5) mummified/skeleton. For further details about stranded specimens, contact the lead author (SE).

5. Training and Education Activities carried out by the NDP

The NDP has worked closely with the local community in 2010 as well as provided training to several students and government staff.

Ms Justina Shihepo has completed her 4th year thesis at U.Nam under the supervision of Prof Omoregie (UNam) and Dr Simon Elwen (NDP and University of Pretoria). Justina used the NDP bottlenose dolphin data to analyse seasonal trends in abundance (data presented above). She spent 6 weeks in the field with the NDP team and learnt various field and lab techniques including boat launching and skippering, taking ID photos of dolphins and behavioural recording. She also learnt some of the key theory and techniques behind developing a photo-ID catalogue of animals including assessing image quality and matching individuals as well as applied mark-recapture techniques to estimate abundance. Justina also attended several strandings of live and dead cetaceans with the team and learn the basic skills of necropsy and data collection from dead animals.

Twelyeta Nangolo is a high school learner at the International School in Walvis Bay. She approached the NDP team and expressed interest in learning more about marine science. Unfortunately her exam time table clashed and she was only able to join the NDP team at sea on one day learning about the processes of field research. She remains in contact with the project and we hope to spend more time with her and her school mates next season.

Sion Iikela is the marine mammal technician at MFMR NATMIRC in Swakopmund and joined the NDP team for 2 dissections of dolphins and RL provided training in 2009 on the use of CPODs fo static acoustic monitoring.

The NDP team attended World Oceans Day on the 8th June 2010 at Swakopmund Municipality and presented 2 posters the attendees (scientists, members of the public and school learners) on whales and dolphins of Namibia.

NDP staff and interns assisted the Coastal Environment Trust of Namibia (CETN) with the winter bird count of Walvis Bay and surrounds (July 2010)

The NDP attended a meeting of the Marine Tourism Association of Namibia and discussed several issues of concern including the potential development of a ‘no-go’ zone for tour boats and the development of a responsible skippers training course. See Section 4 for further details

The NDP interacted regularly with the tourism industry in Walvis Bay and provided companies and skippers with information sheets on the latest available knowledge of the local dolphin populations.

The NDP worked closely with Dr JP Roux (MFMR Lüderitz) to deploy and recover the C-POD hydrophones and provided Dr Roux with basic training of how to set up, download and process the data collected by these instruments.

Working with the WBSN (see Section 4) to increase skills and equipment levels for responding to live and dead stranded whales and dolphins.

Acknowledgements

The Namibian Dolphin Project is deeply indebted to many people without whom this project would not be able to continue. Firstly our funders – Nedbank Go Green, NACOMA, the Mohamed bin Zayed Foundation, the British Ecological Society, the Rufford Small Grants Foundation and the Oceans Research Group and Avnic Trading/Garmin SA.

The Namibia Nature Foundation for supporting our efforts in country notably Chris Brown, Sally Wood, Rachel Malone, Hilma Eiki. Also Rod Braby at NACOMA. Justine Braby, Hannes Holtzhausen and Sion Iikela for keeping us in the loop about strandings.

For the aerial survey specifically, we'd like to thank Joan Cameron and the *Bataleurs* for organisation, Nico Louw flying and the use of his plane; John Paterson and Francois du Toit for filling the observers roles. Also Simon Wearne, Sandra Knop and Philip Hoare their support.

In Walvis Bay: the entire marine tourism industry and all the skippers for their support of our work, lending us boats, equipment, slipway access and sharing dolphin sightings with us at sea. Especially Ingo Venter, Marko Jansen van Vuuren, Francois Visser, Mossie Mostert, Anton and Charmaine Vosloo, Naude and Katja Dreyer, Jeanne Meintjies, Francois du Toit and Neels and Megan Dreyer. Gert, Andries and Konrad at Namib Diving / AluCraft Construction for all the help keeping *Nanuuq* on the water and safe off it. Especially to Mike Lloyd, Orlanda Sardinha and Ute von Ludwiger for sharing their photos with us!

Thanks to John and Barbara Paterson for housing us and organising the trip to Möwe Bay museum – Namibia wouldn't be the same without you. To Gail Wearne, Sue Roux and Peter and Marilyn Bridgeford for a million little favours. Joris Komen and Eugene Marais of the National Museum for assisting us in getting stranded specimens into a museum where they belong. Jeff Slater, Edith Mertz, Michelle Wcisel, and Oliver Jewell for help in the field

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Appendix 1. Full sighting history of all identified bottlenose dolphins in Walvis Bay, Namibia. Blue columns represent gaps between seasons. Cells with [X] show animals not seen since 2008 field season. Orange column shows animals involved in mass stranding event. [XX] indicates death of animal T-017.

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Short Note

Injury and Subsequent Healing of a Propeller Strike Injury to a Heaviside's Dolphin (*Cephalorhynchus heavisidii*)

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The wounds of dolphins and whales are known to heal rapidly and thoroughly in both natural and controlled situations (Bruce-Allen & Geraci, 1985; Corkeron et al., 1987a; Lockyer & Morris, 1990; Bloom & Jager, 1994). Healing rates vary with the severity of the injury but, in general, even the most severe wounds, exposing deep muscle tissue, heal almost completely within 5 to 8 mo (Corkeron et al., 1987a; Bloom & Jager, 1994; Visser, 1999). However, the scars resulting from deep wounds and mutilations along the edges of dorsal fins are known to last for years, and potentially throughout an individual's life (Würsig & Jefferson, 1990), and thus provide a useful set of marks which can be used to distinguish individuals in the field.

Photographic capture-recapture techniques are a powerful way to study wild populations of cetaceans but are reliant on the assumption that one is able to consistently identify individuals over long periods of time. Additionally, frequency, type, and size of body scars on cetaceans have also been used to infer age, sex, and social status in wild populations (Chu & Nieukirk, 1988; Gowans & Whitehead, 2001; Rowe & Dawson, 2008) as well as rates of interaction with other species, particularly predators (Corkeron et al., 1987b; Cockcroft et al., 1989; Gowans & Whitehead, 2001) and humans (Best & Schell, 1996; Best et al., 2001). It is thus important to have some understanding of the healing rate of these injuries. In this note, we report upon a series of observations of the healing of a propeller strike injury to a Heaviside's dolphin (*Cephalorhynchus heavisidii*) and discuss the implications relevant to mark recapture studies as well as conservation concerns.

Heaviside's dolphins are a poorly studied delphinid endemic to the coastal waters of the Benguela ecosystem along the southwestern coast of Africa. This species is known to be locally abundant (Elwen & Leeney, 2009; Elwen et al., 2009) and occurs continuously within its range (Findlay et al., 1992; Elwen et al., 2010). However, they show site fidelity to small home ranges (~50 km along shore) over at least 2 y (Elwen et al., 2006; Elwen, 2008), which may increase their susceptibility to localised threats. Heaviside's dolphins are exposed to a low degree of bycatch in fisheries throughout parts of their range (Best, 2007) and increasing pressure from marine tourism, especially along the central Namibian coast (Elwen & Leeney, 2008).

Walvis Bay, Namibia (22.9S 14.48E), is a north facing, sandy bottomed bay, roughly 10 × 10 km, protected from the open ocean on the western side by a low lying sand spit ending at Pelican Point. Within this bay, 26 tour boats (5 sailing catamarans and 21 catamaran ski boats, 6 to 9 m long) operate marine wildlife watching tours. Although Walvis Bay is a commercial and fishing harbour, these tour boats represent the vast majority of boat traffic that interacts with dolphins in the bay. Two of the principal target species of tour operators are a small population of approximately 77 bottlenose dolphins (*Tursiops truncatus*) and a larger population of approximately 505 Heaviside's dolphins (Elwen & Leeney, 2009). Both species are often observed riding the bow waves of boats and are actively pursued by tour boats to encourage bow or wake riding and maximise interaction with the vessel. All vessels operate under power when in the presence of dolphins, and no "swim with" operations exist in the area. Heaviside's dolphins are viewed on a daily basis at an area of known concentration, roughly 2 km^2 in size, directly north of Pelican Point at the northwestern extreme of the bay.

The injured animal (sex unknown, catalogue number C-021) was observed a total of 11 times and photographed on ten of these occasions between 13 June 2008 and 4 August 2010. The animal has been seen in both summer (February-

March) and winter (June-August) field seasons, suggesting site fidelity to the Walvis Bay area. All sightings except the last occurred within the concentration area around Pelican Point in Walvis Bay; the last occurred along the eastern coast of the bay approximately 27 km northeast. Prior to its injury, the animal had been identified from distinctive markings on its dorsal fin, including two small nicks, a larger square crenellation on the trailing edge of its dorsal fin, and a small white scar, similar in width to a tooth rake, on the top left side of the fin (Figure 1).

When initially observed with the propeller strike injury on 11 and 12 February 2010, the dolphin had nine roughly parallel cuts on its left flank between the front of the dorsal fin and the middle of the tail stock (the most anterior cut is only visible in a single photograph from 6 March). Other than the propeller wounds, the dolphin appeared to be in good health, with smooth skin and no obvious signs of emaciation. A dark lesion, flat to the skin and similar to the "Tattoo disease" described in several other species of cetacean (Van Bressem et al., 2003, 2007) lies on the light grey "cape" of the left fore-flank. This area of the body was not frequently exposed nor was it subsequently photographed, so following the development of this lesion was not possible. The lesion is visible in the very first photograph taken post injury and is thus presumably not related to, or a result of, any ill health associated with the observed propeller wound. Healing rate in dolphins as well as the presence of lesions may be associated with water temperature and salinity (Wilson et al., 1999), with healing occurring more quickly in warmer and more saline waters (S. Ridgway, pers. comm., 25 August 2010). The sea surface temperature (SST) was measured at the beginning of all dolphin encounters using an onboard Garmin 430 Fish Finder, and during those encounters with the injured animal, it ranged between 15.1 and 20.0º C. Salinity was not measured *in situ*, but a scientific cruise in the area during the same time of year in 2003 (Brüchert et al., 2003) reports salinity values of ~35.9 psu.

To simplify descriptions of the wounds, we assigned each cut a number from 1 through 9, starting at the anterior of the dolphin (Figure 1A) and counted all days subsequent to the 11 February 2010 as "days post injury." We calculated the distance between each pair of propeller cuts (except cut 1 which is only visible in a single very angled image) by measuring the distance in pixels (px) between the top insertion of each cut in Adobe *Photoshop CS3*. Pixels were converted to cm by assuming a mean vertical fin height for this species of 15.8 cm (Best & Abernethy, 1994). We calculated that 1 px in this image represented approximately 0.348 mm on the dolphin. Thus, the mean distance between cuts was 7.08 cm (1.28 SD) (cuts 2 and 3 = 8.51 cm, cuts 3 and 4 = 8.44 cm, cuts 4 and 5 = 7.46, cuts 5 and 6 = 7.64 cm, cuts 6 and 7 = 6.38 cm, cuts 7 and 8 = 5.13 cm, cuts 8 and 9 = 5.96 cm). All cuts were relatively short (only cuts 3 through 5 were entirely visible and measured 7.8, 6.8, and 7.6 cm, respectively). The cuts differed in width, with cuts 5 through 8 being the widest and deepest.

On the first 2 d of sighting post injury (11 and 12 February 2010), at least seven of the nine cuts were open (cut 1 not visible; cut 4 did not penetrate the skin), showing pale pink muscle and a clear differentiation between skin, blubber, and muscle tissues. No blood was seen, and differentiating between the shade of the muscle tissue on the 2 d is not possible due to different photo exposure. The cuts were clearly very fresh, however, and it is unlikely that they were made more than 2 or 3 d prior to the sighting. Bloom & Jager (1994) report similarly fresh, nonbleeding wounds on a bottlenose dolphin 24 to 48 h post injury. By the third, fourth, and fifth sightings of the animal on 2, 5, and 6 March (19 to 23 d post injury), skin had already covered cuts 1 through 3. Each of these scars showed a pale centre and dark outline. In cuts 5 through 8, the thick skin layer appeared to be beveled into the cut, with the skin closest to the wound showing a lighter grey colouration and a slightly darker outline at the very edge of the wounds. In cuts 6 through 8, the deepest and widest, the skin has not yet covered the wounds entirely. A layer of granulation tissue is obvious in the bed of the wound (Corkeron et al., 1987a). At the final sighting of the dolphin during the summer field season (22 March 2010, 39 d post injury), the anterior scars all show near-complete healing with the wounds only visible as discolouration on the skin (darker outline; paler centre), with no obvious indentation or swelling. The two deepest injuries (cuts 7 and 8) were the only ones still showing any of the white granular tissue, but they were reduced considerably in size compared to the previous sighting only 16 d prior. The most recent sighting of the injured animal (4 August 2010, 174 d post injury) showed all injuries to have healed and completely repigmented (no white scar tissue), but with the scars clearly visible and protruding slightly from the body (Figure 1H).

Given the size of the cuts, it is most likely they resulted from the propeller of an outboard engine such as those used on the research vessel and tour boats. Propellers for these types of engines range from ~30 to 40 cm rather than the much larger propellers used on the inboard engines of longline and trawler vessels (Beck et al., 1982; Wright et al., 1995). All cuts had the top edge anterior

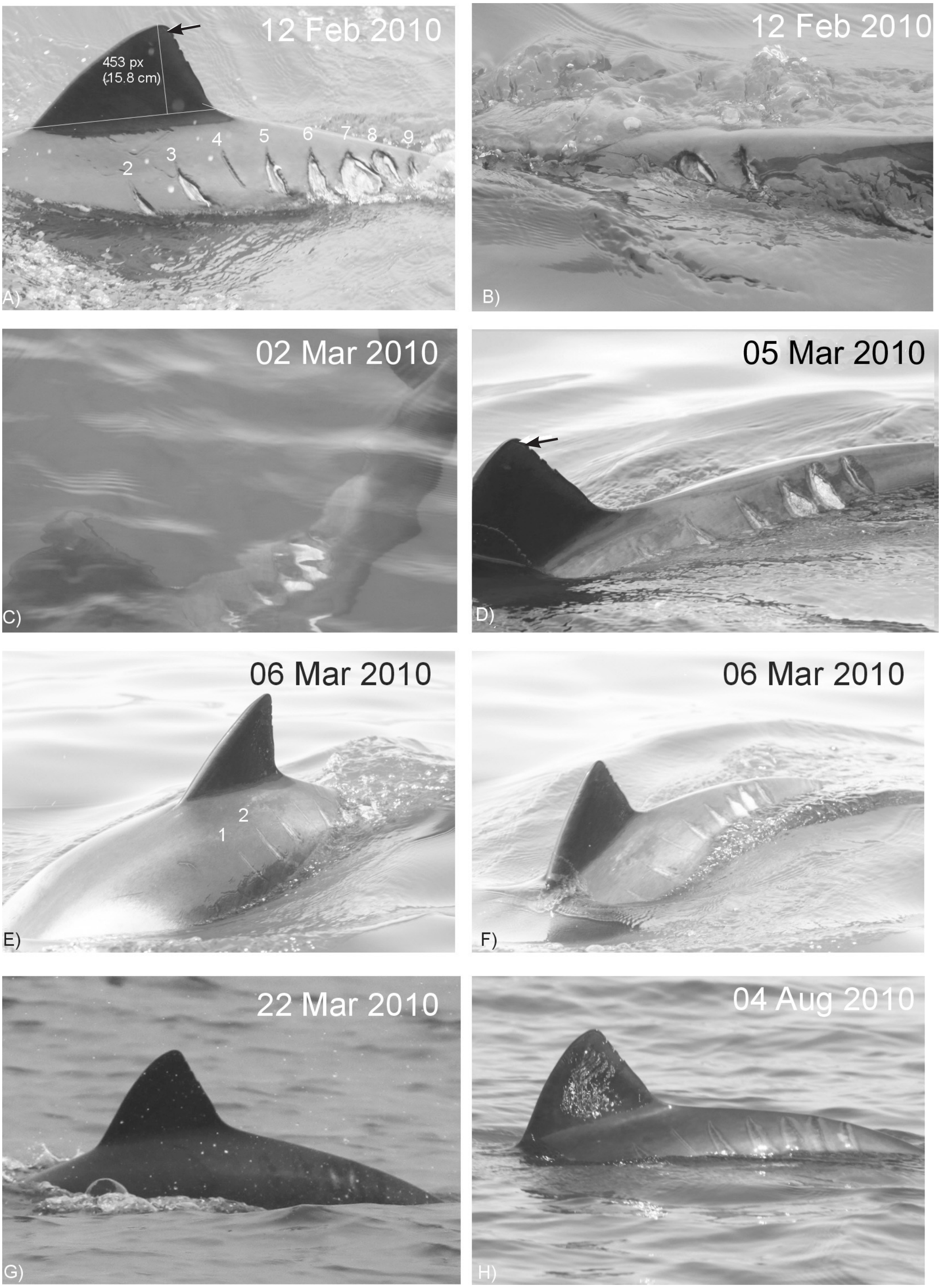

Figure 1. Progression of healing of propeller injury to a Heaviside's dolphin (*Cephalorhynchus heavisidii*) in Walvis Bay, Namibia; top left image used to measure spacing between cuts. Cuts 1 through 9 are labeled in images A and E. Arrows in images A and D indicate unhealed small white scar.

to the bottom edge (slanting forwards on the animal), suggesting that the animal was hit by a boat moving in the same direction as it. This is further supported by the posterior cuts being deeper; presumably the dolphin would move/flinch away from the propeller during the interaction.

The rate of healing of this wound occurred over a similar time frame to that observed in other dolphin species with similarly deep wounds. A shark bite wound at least 3 cm deep on the flank of a bottlenose dolphin in New Zealand closed completely within 30 d and healed to a scar within 45 d (Orams & Deakin, 1997). A severe wound to the top of the head of a bottlenose dolphin, which was caused by the skeg of an outboard engine, healed to a white scar within 3 mo (Lockyer & Morris, 1990). A propeller wound to a bottlenose dolphin in UK waters showed a slightly slower healing rate than that reported here, with some wounds still being open after 65 d, and complete healing to scars taking more than 100 d (Bloom & Jager, 1994). The slower rate of healing in this animal may have been related to a number of infections and abscesses observed in the wounds, the low water temperatures in winter (4 to 5º C), and high levels of bacteria associated with a sewer outfall in the region (Bloom & Jager, 1994).

Some instances of cetaceans learning to associate a boat with adverse conditions such as biopsy (Barrett-Lennard et al., 1996) or capture (Irvine et al., 1981) have been reported. However, the majority of studies have shown no long-term behavioural changes to short-term impacts or injuries (Weinrich et al., 1991; Weller et al., 1997; Krützen, 2002; Best et al., 2005). Despite such a recent and extensive injury, the dolphin reported on in this study readily approached the research boat and surfed the bow wave on several occasions, including when first seen post injury. Heaviside's dolphins actively interact with boats, readily surfing both the bow wave and wake. In the high density area north of Pelican Point, Heaviside's dolphins may be exposed to up to 12 vessels at a time, all actively seeking dolphin interactions (Elwen & Leeney, 2008). Although intense, the period of interaction is relatively brief over a 24-h period, with tour boat numbers peaking between 0900 and 1200 h, the duration of trips being curtailed by generally strong winds in the afternoon (Elwen & Leeney, 2008). That only one animal has been seen with propeller strike injuries despite a daily exposure to tour boats in this area suggests the risk of direct injury may be relatively low. The combination of a relatively large population, the high concentration of animals at Pelican Point, and the relatively short period of interaction time with boats likely reduces the encounter rate of individual animals with boats, despite the daily exposure.

Although dorsal edge injuries are usually regarded as effectively permanent (Würsig & Jefferson, 1990), superficial scarring, such as the small white scar on the tip of the left side of the dorsal fin (Figure 1) or those caused by tooth rakes, is generally thought to heal completely within several months (Lockyer & Morris, 1990). In contrast to the rapid healing of the propeller wounds, no discernible change in shape, size, or colouration of either the dorsal edge marks or the white dorsal scar was observed over the nearly 800 d of observation. The implications of these observations for long-term photo-identification studies are positive: (1) our data suggest that even small scars on the dorsal fins of Heaviside's dolphins may be useful for confirming identity in conjunction with dorsal edge marks over periods of several months to years, and (2) although the healing rate of deep wounds such as from a propeller is rapid, the scarring is still clearly visible for several months. This suggests a reasonable time frame within which assessments of the frequencies of various injuries such as those caused by shark bites or entanglements may be estimated accurately.

Acknowledgments

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Interactions between leatherback turtles and killer whales in Namibian waters, including predation.

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Abstract

Killer whales and leatherback turtles are infrequently sighted in the coastal waters of southern Africa. Year round observations in Walvis Bay, Namibia of killer whales (2003-2010) by multiple marine tour operators and opportunistic seasonal observations of leatherback turtles made during a cetacean research project in the area (2008-2010) have been collated. Visits to coastal waters by killer whales (n = 16) are sporadic and unpredictable but are slightly higher (n = 11) between late winter (August) and late summer (March). Leatherback turtles were only seen in the warmer periods of summer months (February - March) when the surface waters exceeded 15˚C. Two interactions (one harassment and one probably predation) between killer whales and leatherback turtles have been recorded in Walvis Bay. This is the first report of killer whales eating leatherback turtles in the South Atlantic. These observations are noteworthy due to the low frequency of encounters of both species in the area suggesting predation of turtles may be relatively common. Knowledge of the diet of killer whales is valuable due to the importance of dietary specialization in definition of ecotypes of the species.

In press – South African Journal of Wildlife Research

Using Static Acoustic Monitoring to Describe Echolocation Behaviour of Heaviside's Dolphins in Namibia

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In Press – Aquatic Mammals

Abstract

Static Acoustic Monitoring is a cost-effective, low-effort means of gathering large datasets on echolocation click characteristics and habitat use by odontocetes. Heaviside's dolphins (*Cephalorhynchus heavisidii*) were monitored using an acoustic monitoring unit, the T-POD, in July 2008, at a site of known high abundance for this species in Walvis Bay, Namibia. The T-POD successfully detected clicks from Heaviside's dolphins, and these clicks were detected in the 120-140 kHz frequency range. A distinct diel pattern to the mean hourly mean inter-click interval was observed, with higher values during daylight hours than at night, suggesting that click trains are produced at faster rates at night time. There was no apparent diel pattern in the proportion of buzz trains produced, however. A diel pattern in click activity was observed, with many more detection-positive minutes per hour recorded between dusk and dawn, and vocalization activity dropping to low levels in the middle of the day; this corresponded with visual observations made on abundance of dolphins in the study area. These results suggest that Heaviside's dolphins use this site primarily during the night. Static Acoustic Monitoring proved to be an effective technique for monitoring patterns of habitat use by Heaviside's dolphins.

Keywords: *Cephalorhynchus heavisidii*, click train, echolocation behaviour, habitat use, inter-click interval, T-POD

Individual variation in bottlenose dolphin ranges in Walvis Bay, Namibia. Implications for managing restricted areas.

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In review – African Journal of Marine Science – Special Issue on Cetaceans

Abstract

There are approximately 70-100 bottlenose dolphins (*Tursiops truncatus*) inhabiting the shallow 100 km^2 area of Walvis Bay, Namibia. This study determined the habitat utilization as well as the ranges of individual bottlenose dolphins from this area, with the overall aim of evaluating the potential for delineating a protected area in which boat traffic could be restricted in areas where the most impact-sensitive behaviours (e.g. resting) are performed. Boat based mark-resight surveys and photo-identification techniques used in conjunction with sightings locations and behavioural observations allowed range plots for each individual using kernel methods as well as defining animal ranges using ArcGIS 9.3 software. Habitat use patterns varied considerably among seasons and individuals but over the longer term, two key habitats were identified. Feeding and socialising behaviours were observed to occur throughout the bay, but resting behaviour occurred predominantly in one of the key areas. Individual recognition showed this area to be used by the majority of individuals (86%) and all mother-calf pairs, thus fitting all identified needs for a protected area. The implications of this area for the dolphin population and marine tourism industry were considered when proposing a protected area.

Keywords: Bottlenose dolphins, Walvis Bay, tourism threats, habitat utilization, conservation area, behaviour.