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Using Signature Whistles to Investigate Population Dynamics of Locally Threatened Bottlenose Dolphins *(Tursiops truncatus)* in Namibia

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Project Background

Namibia is known for its rolling dunes and desert landscapes. These dunes often roll right into the sea, and into a coastline that hosts an incredibly diverse assemblage of species. Some of the more easily observed wildlife can be seen at the Walvis Bay lagoon, an internationally recognized conservation site for wading birds, or at Cape Cross and Pelican Point, which host immense colonies of Cape fur seals (*Arctocephalus pusillis pusillis*). The Namibian Dolphin Project (NDP) studies a more cryptic order of animals, cetaceans (whales and dolphins), which are resident to, or migrate through, the coastal waters of

Namibia. Founded in 2008, NDP's research investigates a range of questions including the sound production and behaviour of common bottlenose dolphins (*Tursiops truncatus*), Heaviside's dolphins (*Cephalorhynchus heavisidii*), and humpback whales (*Megaptera novaeangliae*). The focus of one of our more recent projects is to develop a method to estimate abundance, density, and movement patterns of dolphin populations, using a specific type of whistle produced by some delphinids, the signature whistle (Janik et al., 2013; Kriesell et al., 2014). We have termed this method, SWORD: Signature Whistles for Occurrence, Recapture and Density (Gridley et al., in prep).

Focal Species

Common bottlenose dolphins, (*T. truncatus*; hereafter 'bottlenose dolphins') are an abundant species with a global distribution. A small, isolated, population of bottlenose dolphins is resident to Namibian waters (Fig. 1). These animals have a very coastal distribution, rarely seen in water more than 15 metres deep and as shallow as a half a metre. Globally, bottlenose dolphins are considered 'least concern' on the International Union for Conservation of Nature (IUCN) Red List, however, they often form small, isolated

Figure 1: A group of bottlenose dolphins (Tursiops truncatus) *travelling along the arid Namibian coastline. This coastal population, numbering less than 100 individuals, is rarely seen in depths of more than 15 metres and ranges between Lüderitz and Möwe Bay.*

populations which can be of much higher conservation concern (Currey et al., 2009). The Namibian population of bottlenose dolphins is regionally unique and is under pressure from harbour activity and construction, tourism, and possibly recreational fishing. The most recent population estimate suggested fewer than 100 individuals (Elwen et al., 2019), which makes them one of the smallest populations of mammals in southern Africa and among the most vulnerable, underscoring the need for strict conservation measures to support population management. They could be considered in a similar light to the Namibian desert lions (Stander, 2019), in that this is a locally unique population of a more abundant species.

Project Development

Current research methods for studying dolphins rely heavily on boat-based surveys using photographic identification (photo-ID) of individual's unique features such as scarring and marks on dorsal fins. By building up a sightings history of individuals, we can apply mark-recapture statistical methods to investigate ranging patterns, survivorship, and population abundance. However, these boat-based methods are inefficient for small, widely spread populations such as the Namibian coastal bottlenose dolphins which range over at least 400 km between Lüderitz and Walvis Bay. Therefore, we aim to develop a framework using biological sounds and a spatial capture-recapture approach (Borchers, 2012) to assess population density and abundance of Namibian bottlenose dolphins, contributing to long-term monitoring of this population.

Cetaceans use acoustic communication to mediate their social interactions (Popper, 1980; Herzing, 1996). Acoustic monitoring of general vocalisations is a widely used method to provide information on species presence and, to some extent, behaviour. However, some dolphin species have been known to also use individually distinctive 'signature whistles'(Janik, 2013), which have similarities to names in human society. Signature whistles, first described in 1968 (Caldwell et al., 1968), are used as contact calls and to facilitate reunions within the group (Janik, 2013). These individually unique signals are developed within the first year after birth (Sayigh et al., 1990) and are stable for up to 18 years, and most likely for life (dos Santos et al., 2005). By using unique signature whistles to monitor individual dolphins in their natural environment, our approach offers a substantial improvement on current monitoring methods. The deployment of hydrophones (underwater microphones) along the coast for extended periods of time will acoustically "capture" individual dolphins if they are producing their signature whistle as they swim by. Capture histories of signature whistles will enable cost-effective and robust monitoring of threatened populations at an individual level, improving abundance estimates. We also aim to generate information on individual movement, identify ecologically significant high-use areas and gain an understanding of social relationships, in locations and time frames previously inaccessible.

Our team aims to develop this novel methodology for its use on other threatened coastal delphinid species. The proof of concept for this method has been completed, demonstrating that capture-recapture estimates of signature whistles produce similar results to estimates generated through standard photo-identification methods (Longden et al., 2020). The Namibian Dolphin Project (NDP) has conducted 12 years of photo-ID (Elwen et al., 2019) and has a developed catalogue of known signature whistles (Kriesell, 2014). The acoustic repertoire is well understood (Gridley et al., 2015; Heiler et al., 2016), as well as their vocal behaviour and the spatial variation in signature whistle production and detection (Longden et al., 2020).

Methods

Acoustic data for the study was collected in Namibian coastal waters between Sandwich Harbour and Cape Cross from June to August of 2021, an area which represents the known core range of the species. The NDP's existing photo-ID and signature whistle catalogue will be used to generate signature whistle capture histories and statistical analyses. It should be noted that spatial capture-recapture models are able to cope with home ranges that extend beyond the survey limit (Borchers, 2012).

Figure 2: A SoundTrap 300HF (Ocean Instruments Inc., NZ) hydrophone used to make underwater recordings of the bottlenose dolphins (T. truncatus).

Acoustic data was collected using an array of six SoundTrap hydrophones (Ocean Instruments, Inc., NZ) and 10 AudioMoth hydrophones (Open Conservation Technology Ltd., UK) on a static mooring system (Fig. 2). They recorded at a sample rate of 96 kHz, above the maximum frequency of whistles for this population (maximum 23.24 kHz; T. Gridley, 2015), and can record for between five and 64 days depending on the device used and duty cycle chosen. Simultaneous deployments were made each month (June, July, August) at five locations: Sandwich Harbour, Walvis Bay (four sites), Swakopmund, Henties Bay, and Cape Cross.

Recordings were processed using PAMGuard (Gillespie et al., 2009) to identify periods of acoustic activity and extract individual whistles. These whistles were

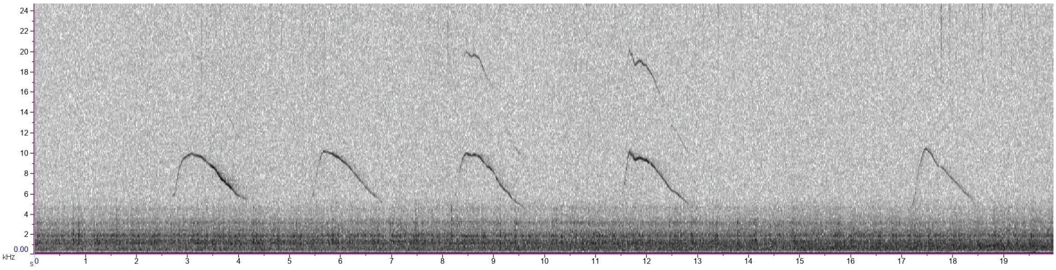

Figure 3: In this spectrogram, five bottlenose dolphin (T. truncatus) *whistles are shown. Following the SIGID method (Janik et al. 2015), these whistles would constitute a signature whistle type. There are four or more stereotyped whistles, and three of the four occur within 10 seconds of the previous whistle.*

manually investigated in Raven Pro v1.6 (Bioacoustics, 2019) and matched to a signature whistle type (SWT) in our existing catalogue or assigned a novel SWT using a well described method for identifying signature whistles in free-ranging populations; SIGID (Janik, 2013). This uses call classification and a sequence analysis approach applied to whistles produced in bouts (Fig. 3). We use the individually unique SWTs as the identifying marker to generate capture histories. These capture histories of SWTs (assumed individuals) are used in three types of statistical analyses: spatial capture-recapture modelling, using the R-package oSCR (Sutherland et al., 2019); mark-recapture modelling, using Program: Mark (White et al., 1999); and social network analysis, using SOCPROG (Whitehead, 2009). From these, we were able to estimate density, abundance, high-use areas, movement patterns, and social affiliations (Fig. 4).

Conservation Outputs

The small numbers in this population allow us the opportunity to monitor the population status at the individual level as well as develop a research tool that might be used on other at-risk populations or species. This approach is vital for Namibian bottlenose dolphins as bottlenose dolphins are generally classified under 'Least Concern', however, locally restricted populations such as this can also be critically endangered. Through our statistical analyses, we aim to identify high-use areas and provide a method to effectively monitor population trends. Our research will contribute to understanding dolphins in Namibian waters and help to create protective measures for this at-risk population, contributing to local and international management. Knowledge of an individual animal's movements and activity centres, such as areas of high use by mother-calf pairs, is critical data for developing effective conservation practices. Development of passive acoustic monitoring (PAM) systems used to collect data on naturally occurring acoustic labels will allow us to develop direct, fine-scale protective measures. This method

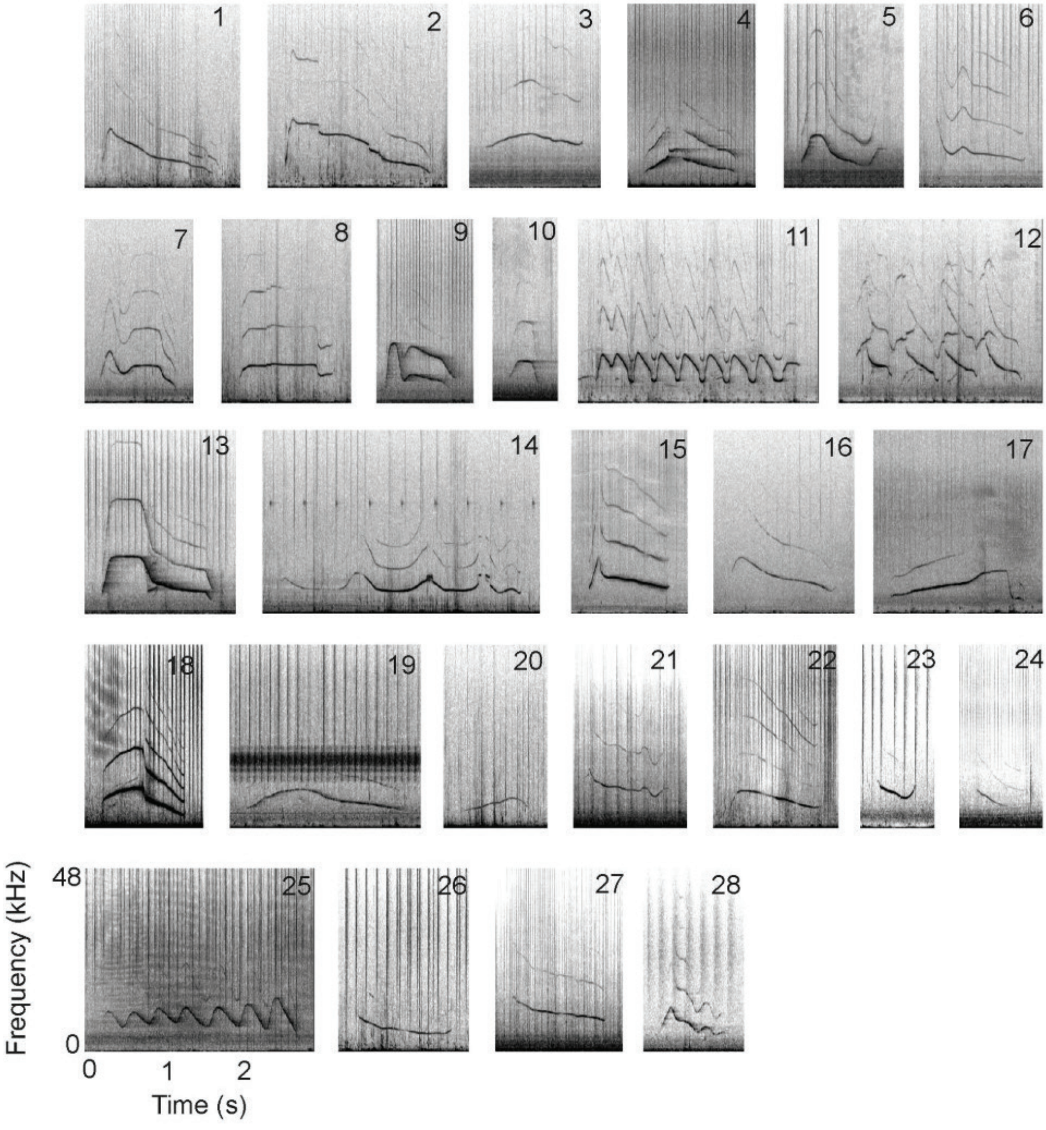

Figure 4: A portion of the Signature Whistle Catalogue held by the Namibian Dolphin Project. These whistle types were identified in 2014 (Kriesell et al., 2014), and the catalogue now holds over 80 SWTs.

can then be transferred to other species, marine or terrestrial, that have unique vocal signatures.

Bottlenose dolphins are one of the top predators within the Namibian marine coastal ecosystem and the population potentially plays an important role in trophic regulation and ecosystem management (Bejder et al., 2006; Heithaus et al., 2008). It has been widely shown that top predators are the key species in maintaining balance in food webs and for ecosystem health. Additionally, genetic stochasticity is a severe risk for small populations like the Namibian bottlenose dolphin population. A current assessment is being undertaken by B. James (in prep) to investigate the genetic health and heterogeneity of the population. When the numbers of a population drop to a certain point, recovery becomes exceedingly difficult. The loss of one calf or breeding individual to a ship strike or natural causes has a relatively larger impact than it would in a large healthy population. This population is known to forage in a tidal lagoon at the southern side of Walvis Bay, and numerous live strandings have been reported, mostly resulting in successful refloatations of the individuals (McGovern et al., 2020). Harbour activities and construction have continued, and an increase in industrial harbour activities could potentially cause the dolphins to use the risky lagoon to forage more often, increasing the likelihood of stranding events. Due to their ecological importance and at-risk status, it is necessary that we take every effort to promote conservation.

Promotion of conservation of our marine ecosystem can in turn support a growing marine tourism industry. The global whale-watching industry, according to a 2009 estimate, generated 2 billion dollars (USD) and was set to grow at 10% each year (O'Connor et al., 2009). Second only to the mining industry, tourism is the fastest-growing sector of Namibia's economy. As of the last review of the industry in Walvis Bay, eight tour companies, operated 27 boats and over 60,000 passengers every year, generating almost N$30,000,000 (Data from 2010) (Leeney, 2014). Restaurants, hotels and shops also rely on marine tourism to attract customers. Our continued involvement in the conservation of our marine fauna is welcomed and encouraged. The tourism industry has been significantly reduced, due to COVID-19, with only between two and four boats operating on any one day in early 2021, but there have been strong signs of recovery by November. A reduction in tourism activity may have a beneficial effect on the wildlife populations in the area, including the bottlenose dolphins (Arora et al., 2020). This project will help us continue to contribute to responsible tourism practices, beneficial for both the wildlife and the economy.

Once developed, the SWORD proposed methodology would be applicable to other resident populations of odontocetes that use signature whistles (e.g., common dolphins (Fearey et al., 2019), humpback dolphins (Van Parijs et al., 2001), belugas (Morisaka et al., 2013), or other species with individually unique acoustic labels (Fig. 5). Our goal is to develop a method to monitor small populations to the individual level in a cost-effective, comprehensive, and accurate way. We believe that this method will enable other researchers or conservationists to do that. Passive acoustic monitoring is a growing industry with

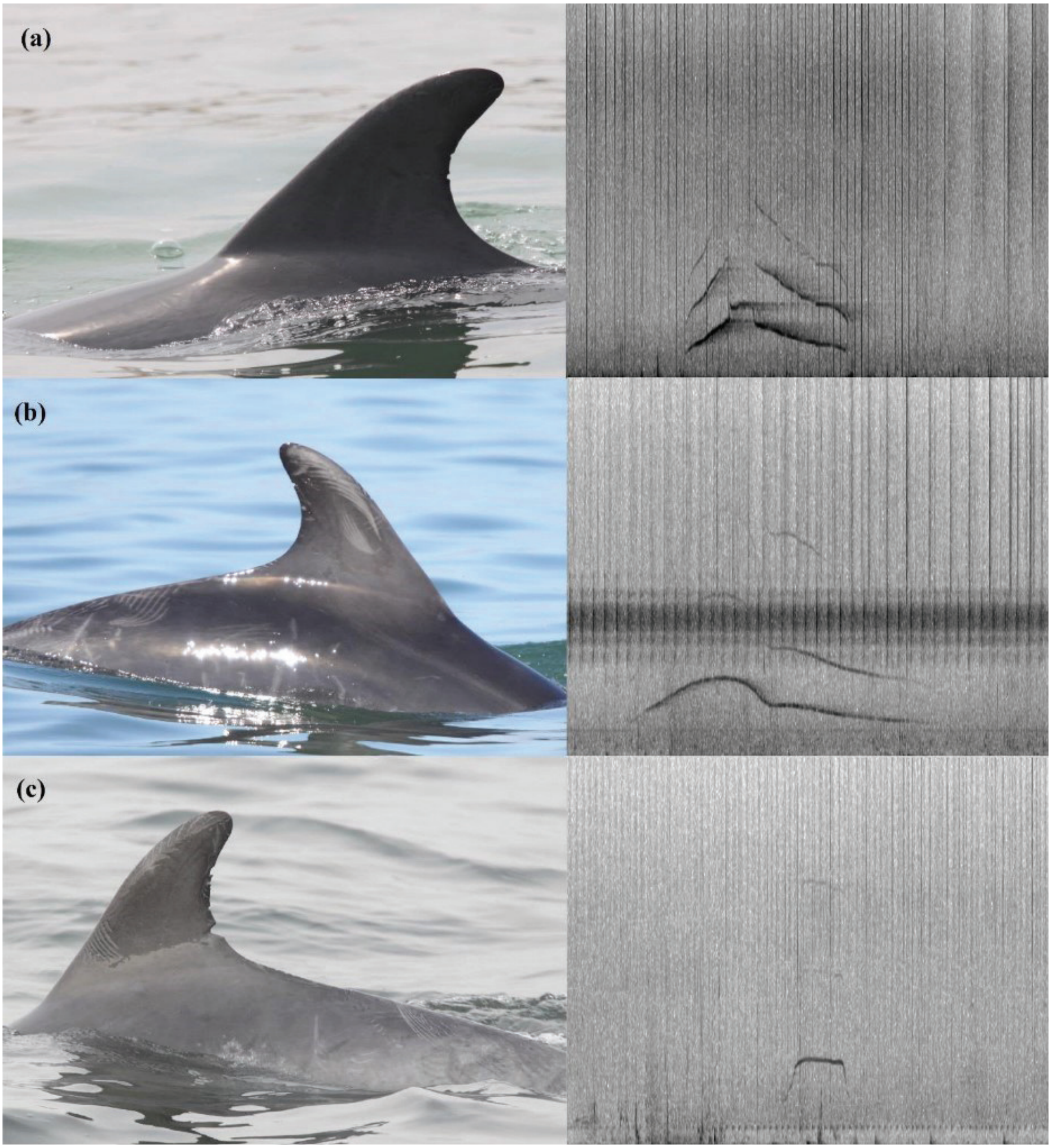

Figure 5: A signature whistle type is unique to each individual, allowing them to be used as an identifying marker, similar to how dorsal fin marks are used to identify individuals in the Photographic Identification method (Rashley et al., unpublished). (N.B. These SWTs do not necessarily belong to the dolphins pictured, this graphic is simply for illustrative purposes.)

rapidly advancing technology. Instruments are now available for less than 100 USD (Gordon et al., in press), making them universally accessible. Cost-effective open access hardware, combined with achievable analysis techniques will make acoustic monitoring an effective option moving forward and will benefit a variety of conservation programs, both terrestrial and marine (Fig. 6). It is our aim that SWORD, and the use of signature whistles to estimate population dynamics, will help these conservation programs and a variety of populations and species.

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Figure 6: Jack Fearey is pictured here retrieving one of the SoundTrap recording devices in Namibia after a three-week deployment. The SoundTrap is attached to the rope/buoy system and weighted on the sea floor.

Figure 7: Bottlenose dolphins (T. truncatus) *socialising in Walvis Bay, Namibia. Signature whistles are often produced during social behaviour.*

research as well as the Walvis Bay Yacht Club, DebMarine, TOSCO, NCE and B2Gold for supporting the NDP Marine Education Centre, field office and work vehicle.

If you want to learn more about this project or other work we are doing, please visit the NDP Marine Education Centre, located next to the Walvis Bay Yacht Club and follow us on Facebook @Namibian Dolphin Project. If you would like to support us, please find our donation page with TOSCO (https://tosco.org/).

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Jack Fearey is a PhD candidate at the University of Cape Town, working within two research groups, the Centre for Statistics in Ecology, the Environment Conservation (SEEC) and Sea Search Research and Conservation (SSRC). His PhD is working towards the development of a long term, efficient and cost-efficient method for estimating population dynamics of species with individually distinctive vocalisations. Jack got his undergraduate degree in environmental science from Santa Clara University in California. He has been living in Cape Town, South Africa and Walvis Bay, Namibia, working on his PhD and as a research assistant and student with SSRC and the Namibian Dolphin Project. He has a passion for both acoustics and statistics and hopes that his project will help under-developed countries implement successful conservation strategies for at risk populations.
If you would like to learn more about our work, follow us on YouTube, @Sea Search Research and Conservation.

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