Biodiversity and Conservation Science

Snubfin dolphin census in Yawuru Nagulagan/ Roebuck Bay

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Non-technical summary

A census of snubfin dolphins was recently undertaken in Yawuru Nagulagan/Roebuck Bay Marine Park. The census involved line transect surveys undertaken by vessels with observers recording all sightings of dolphins. In addition, two Commercial Tour Operators took out Dolphin Watch volunteers on one day to record dolphin sightings. Photographs were taken of the dorsal fins of all dolphins sighted to be used to identify individual animals based on the unique shape and markings on their fins. This information can be used to assess the number of dolphins using the Bay over the time period of the census and to gather life history information on individual animals.

Three DBCA vessels covered a total of 604km of survey transect lines over three days (4-6th April 2019), equating to 49 hours of dedicated searching for dolphins. The survey effort resulted in sightings of 116 dolphins (including resights over multiple days) and an encounter rate of 0.19 dolphins per km of transect line. Snubfin dolphins (*Orcaella heinsohni)* were the predominant dolphin species sighted during the census with an encounter rate of 0.15 per km of transect line. A total of 96 individual snubfin dolphins were sighted over the three days (excluding resights) including 10 calves.

Of the 96 individual snubfins identified, 28% (27) of these have been seen in previous surveys. One individual commonly known as Grunge (ID rb025oh) was first sighted on 8th May 2007 and has been seen repeatedly over the intervening 12 years, most recently during this census with a new calf. Most (83%) of snubfin dorsal fins were marked making it possible to recognise them as individuals and making them potentially recognisable in the future if the marks remain stable so that we can track their life history. There were several other long term resights and potential residents both snubfin and bottlenose dolphins. In addition to the 96 snubfin dolphins sighted, four bottlenose dolphins (*Tursiops aduncus*) were sighted from the DBCA led vessels. All bottlenose dolphins had been previously sighted.

An additional three snubfin dolphins and two bottlenose dolphins were identified from the sightings recorded by the Dolphin Watch volunteers on the CTO vessels. The third species of dolphin known to frequent the Bay, humpback dolphin (*Sousa sahulensis*) (mother/calf pair), was also sighted and photographed by Dolphin Watch volunteers which was a valuable contribution to the census. The three species recorded in the census are important to maintaining the target of species diversity within the marine park.

Most dolphins were sighted in the northern (Inner Anchorage) and eastern portions of the Bay. The bottlenose and humpback dolphin sightings were closer to Town Beach and Dampier Creek. A higher density of snubfin dolphins was found around Crab Creek and the eastern side of the Bay over the extensive mud flats in water <5 metres.

This trial demonstrates that a rapid population census done with high intensity survey effort over a short period (days) may be appropriate in monitoring trends in abundance of the population over time (years). We recommend that the census-style survey is repeated every 2-3 years (maximum 5 yearly) to ensure that any changes to dolphin populations would be detected and managed. Regular survey effort will also be necessary to track the evolving dorsal fins ('natural tags') which will improve our understanding of the individual life histories of snubfins. Dolphin Watch volunteers that have been trained in the Dolphin Watch app could contribute valuable data, particularly with high resolution dorsal fin photos, in this regard to complement the periodic high intensity surveys.

Introduction

One of the largest populations of snubfin dolphins (*Orcaella heinsohni*) estimated to be ~130 individuals inhabits Roebuck Bay in Broome, Western Australia. In 2016, the Yawuru Nagulagan/ Roebuck Bay Marine Park (YNRBMP) was gazetted. The management plan for the YNRBMP recognizes snubfins as a key value within the marine park with targets to maintain their abundance. A Finbook containing photos of over two hundred individual snubfin dolphin dorsal fins was published under the Dolphin Watch Program of DBCA as a tool to assist in the ongoing monitoring and management of the snubfin dolphin population using their natural marks as tags. These photo-identification images are curated by the Marine Science Program using the DolFIN database.

The Roebuck Bay population is also identified as a National priority for long term monitoring in the National Tropical Dolphin Strategy. A baseline abundance estimate was provided by (Brown et al., 2014a, Brown et al., 2014b) for this population, however regular monitoring is required to ensure that the population is maintained long term, particularly as pressures increase in the region. To this end, we planned a rapid population census to provide a direct count of how many snubfins were in Roebuck Bay and to better understand which individuals remain in the population as a trial technique for long term monitoring. Our rationale for this approach was threefold; first it provides a complete snapshot of the number of animals using Roebuck Bay at a given time, second, it provides for capacity building for the marine park joint partners who participated in the surveys and third, it meets communication and education objectives by involving the community in new citizen science strategies.

Methods

Study area

Roebuck Bay is a large tropical embayment (~500km^2) adjacent to the township of Broome in the Kimberley Region (Figure 1). The Bay is fed by freshwater inputs from Dampier and Crab Creeks as well as many smaller tributaries. The coastal edge of the Bay is relatively shallow <10m water depth at lowest astronomical tide but the Bay is subject to some of the largest tidal movement in the world with a maximum of 10 metres during spring tides meaning that a large portion of the bay is exposed mud flat at low tide and unavailable to dolphins. The benthic substrate is predominantly mud and silt interspersed with seagrass and mangroves lining the periphery of the Bay.

Data collection

We concentrated our survey effort in the northern portion of the Bay (~100km^2) and followed the same two transects designed by Brown et al. (2016) with additional transects added to cover the middle part of the Bay and southern section towards Bush Point (Figure 1) (Transects RB1-5). These additional transects were added to cover more of the Bay and a broader range of habitat types to get a better understanding of snubfin distribution across the Bay and use of these habitats. Pre-determined transects were used to achieve even coverage across the Bay and to ensure data were comparable to Brown et al. (2016). Surveys were conducted and data collected over three consecutive days from 4-6th April 2019. This time of year was chosen to avoid the wet season, the end of cyclone season, to increase the likelihood of low winds (sea state <3) and no rain to ensure photographs could be taken and also to be comparable to one of the two sampling periods used by Brown et al. (2016).

Three DBCA led vessels were used concurrently each day and on the last survey day (6th April) two commercial tour operated (CTO) boats assisted with the survey effort, bringing the total fleet to five

vessels. The vessels included the DBCA *Pinyjiri* and *Linygurra* and the DoT *Sealegs*. The Sealegs boat used on the 4th of April was replaced with a chartered TAMS vessel on the 5-6th April. All dedicated survey vessels were centre console aluminium hulls with twin motors. The CTO vessels were the Broome Whale Watching '*Ballena'* a catamaran operated under power and Absolute Ocean Charters '*Contessa C*' a 20m monohull aluminium cruiser.

The research teams consisted of a Marine Science Program DBCA lead on each vessel and crew and field support from West Kimberley District and MSP DBCA staff and NBY country managers. Each DBCA vessel was given a different transect to cover to achieve spatial separation across the survey area. Vessels maintained 8-10knots while on transect but slowed during dolphin sightings and transited between transects at faster speeds. The CTO vessels concentrated in the northern portion of the Bay in their normal area of operation and did not follow pre-determined transects or speed restraints. Registered and trained Dolphin Watch volunteers were positioned on the CTO vessels and accompanied by DBCA support staff to record dolphin sightings using the Dolphin Watch app.

A minimum of three people were onboard each vessel including the skipper and two observers dedicated to scanning for dolphins (with the naked eye) ahead and on each side of the vessel. When dolphins were sighted the point where the transect was left was noted by the skipper using the onboard navigation system and the dolphin group was approached to collect data on group size, composition (i.e. species, gender and age class) and behavioural activity. The location (latitude and longitude) of the sighting was recorded using a hand held Garmin GPS.. Photographs of the dorsal fins of all dolphins in the group were taken for the purpose of photo-identification of individual animals. A dolphin group was defined as members within 100m of each other and engaged in the same behavioural activity, as per Parra (2006). Each vessel had at least one person using a DSLR camera with a 400mm zoom lens for photo-identification.

Analysis - Distribution of sightings, group sizes and encounter rates

A GPS onboard the vessel was set to automatically record the position periodically of the survey track so that the total distance on and off survey effort could later be calculated. Vessel track points were downloaded at the end of each survey day and converted into transect lines in GIS. All survey effort on transects were then summed to calculate a total survey effort (linear distance) for the entire census. The total number of each dolphin species (including dependent calves) recorded during the survey was then divided by the total survey effort (linear distance) to produce a metric of number of dolphins encountered per km by species. Maps were produced illustrating the locations of dolphin sightings using QGIS and ArcGIS v10.6 with the Xtools extension. For display purposes the total number of dolphins (including dependent calves) for each 1km grid cell was then divided by the total survey effort of track length for that corresponding 1km grid cell to illustrate dolphin density.

Processing of photo-identification images

Individual dolphins were identified from photographs primarily based on patterns of nicks and notches on the trailing and leading edge of the dorsal fin as well as secondary marks such as pigmentation, scars, rake marks, wounds and lesions on the surface of the dorsal fin. Scars, wounds and lesions on other parts of the body visible at the surface were also used when present. All photographs were qualitatively analysed for focus, contrast, angle, visibility and proximity of the fin and the best photos of each individual were retained. Rigorous grading of photos was not performed for the purpose of this project as the objective was to identify the maximum number of individuals and therefore rules were relaxed (to an extent) around angle and partial fins being obscured by

water, with these photos being retained where they could be used to identify an individual. It would be prudent to exclude these data if used in future in mark-recapture abundance estimation.

Proportion of distinctly marked individuals in the population

Individuals were categorised by the degree of marks on the dorsal fin as either distinctive (D1), subtle (D2) or clean (D3). The overall number of clean fins was calculated for each group and for each day, however, the same clean fin individuals could potentially have been resighted between days as they had no distinguishing features.

Identification and resighting rates

All images and sighting information were entered into the DolFIN database. Attempts to match individual dolphins to those already in the photo-identification catalogue were made by two researchers independently. If a match was not made, then the individual was added to the photo-identification catalogue and given a new ID code.

Results

Survey effort

Surveys were only conducted when environmental conditions were favourable with winds <10 knots and sea state ≤ three (Beaufort scale). Survey effort mostly occurred between 0700 and 1600. Spring tides were chosen as this reduced the survey area to be covered during low tides as a large portion of the Bay becomes exposed mud flats which we anticipated would concentrate snubfins into a smaller area. High tides were around noon to early afternoon during the study period.

A total distance of 953.7km was covered during 76.2 hours over the 3 days of the census. This included 604km of survey effort on set transect lines and an additional 349.7 km during transits to the start point and between transects and when returning to the launch point. A total of 168 dolphins including calves were sighted through the course of the census, 116 while on transect and an additional 52 during transit periods. However, this included repeated sightings of some individuals over multiple days. Once these duplicates were removed, the census resulted in 93 individual snubfin dolphins and 4 bottlenose dolphins sighted from the DBCA led vessels. An additional three snubfin dolphins, two bottlenose dolphins and two humpback dolphins (mother/calf pair) were sighted by the CTO vessels that were not sighted by the DBCA vessels.

A total of 604km of survey effort was completed on transect lines by the three DBCA led vessels over three days (4-6th April 2019) during a total of 49 hours of dedicated searching for dolphins. The survey effort is represented visually in a heat map Figure 1 which shows the relative survey effort in 1 km grid cells across the Bay. Effort was relatively even across the northern end of the Bay with slightly more effort on the eastern side of the Bay and at transect turns and where transects crossed. Transect one and two in the northern part of the Bay were repeated the most (three times) across the three days. Less survey effort was achieved across the middle of the Bay and the least effort undertaken in the south eastern corner towards Bush Point.

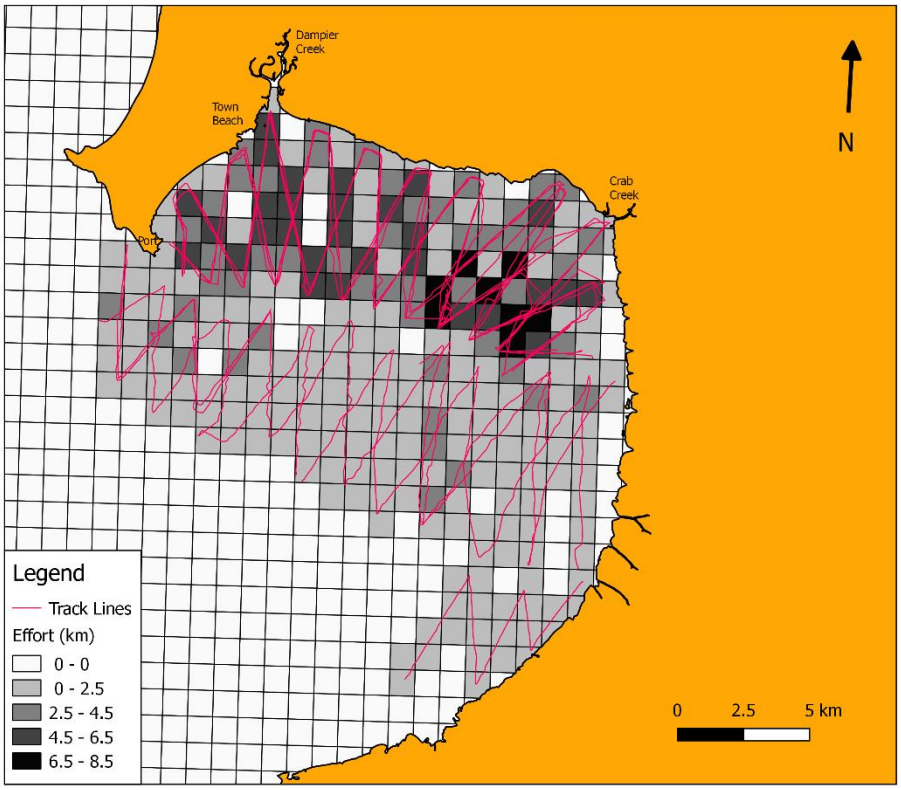

Figure 1- Map showing survey effort with heat map of density of track lines by 1km square grid cells (following pre-determined transects) completed by the DBCA led vessels with actual track lines depicted.

Distribution of sightings and group sizes

Most dolphin sightings occurred in the northern (Inner Anchorage) and eastern portion of the Bay (Figure 3). The bottlenose and humpback dolphin sightings were closer to Town Beach and Dampier Creek. A higher density of snubfin dolphins was apparent around Crab Creek and the eastern side of the Bay over the extensive mud flats in water <5 metres (Figure 3). The only humpback dolphins were sighted by the CTO vessel. Group sizes for bottlenose and humpback dolphins were small, 4 and 2 respectively. A total of 43 snubfin dolphin groups were sighted with group size ranging from one to 17 individuals with a mean of 3.9. The most frequently sighted grouping was of single individuals with a few large groups of 10 or more (Figure 2).

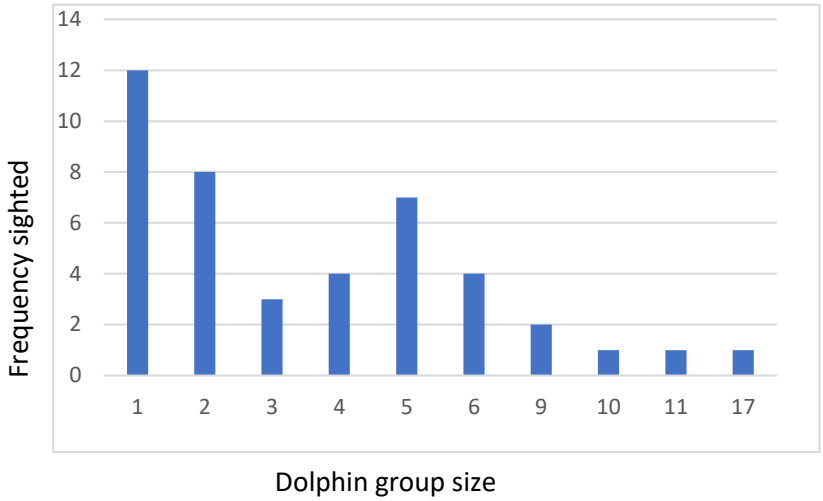

Figure 2 – Number of times different dolphin group sizes were sighted.

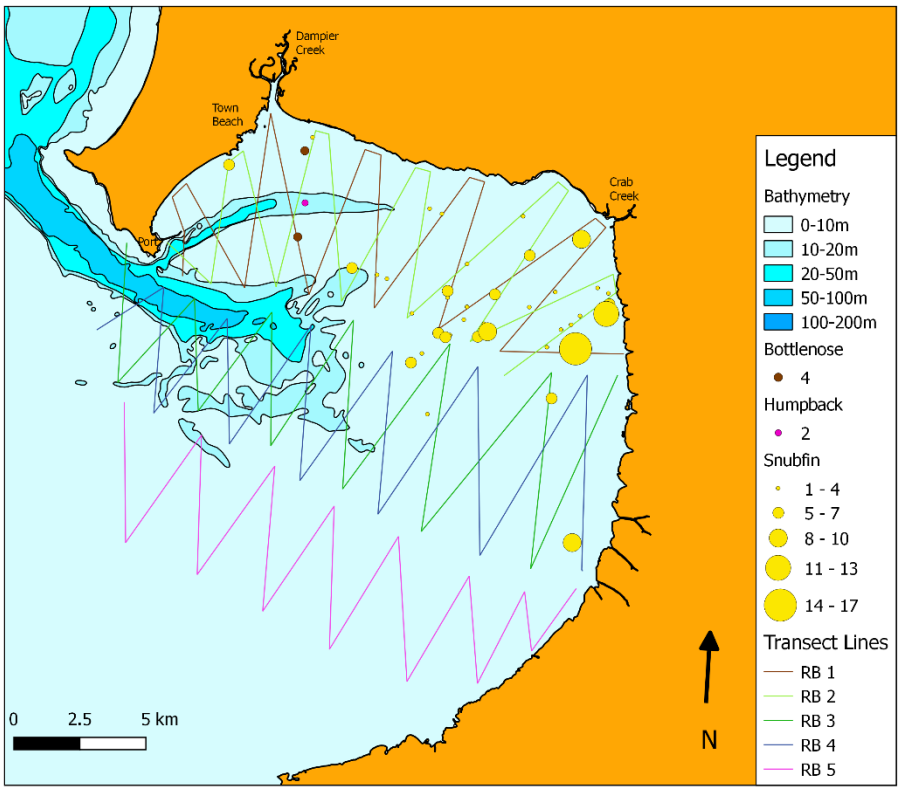

Figure 3 – Sightings of all dolphin species recorded during the survey, snubfin (yellow circles), bottlenose (brown circles), and humpback (pink circles) with group size noted by the size of the circle and bathymetry overlaid.

Encounter rates

The overall encounter rate during the census was 0.18 dolphins per km (approx. 2 dolphins per hour) when using the total track effort (953.7km) that included both the transect line and the non-survey effort component. When only the data from the transect lines was used, the survey effort resulted in sightings of 116 dolphins and an encounter rate of 0.19 dolphins per km of transect line (approx. 2 dolphins per hour). The encounter rate for snubfin dolphins was 0.15 per km of transect line. When assessing snubfin density across the Bay to detect important areas, we found that the encounter rates varied from low, mostly 1-4 dolphins per km, to a few hotspots with 9-15 dolphins per km. The high density encounter areas of snubfins (Figure 4) highlight the important area in the Eastern side of the Bay and also an area in the middle part of the Bay.

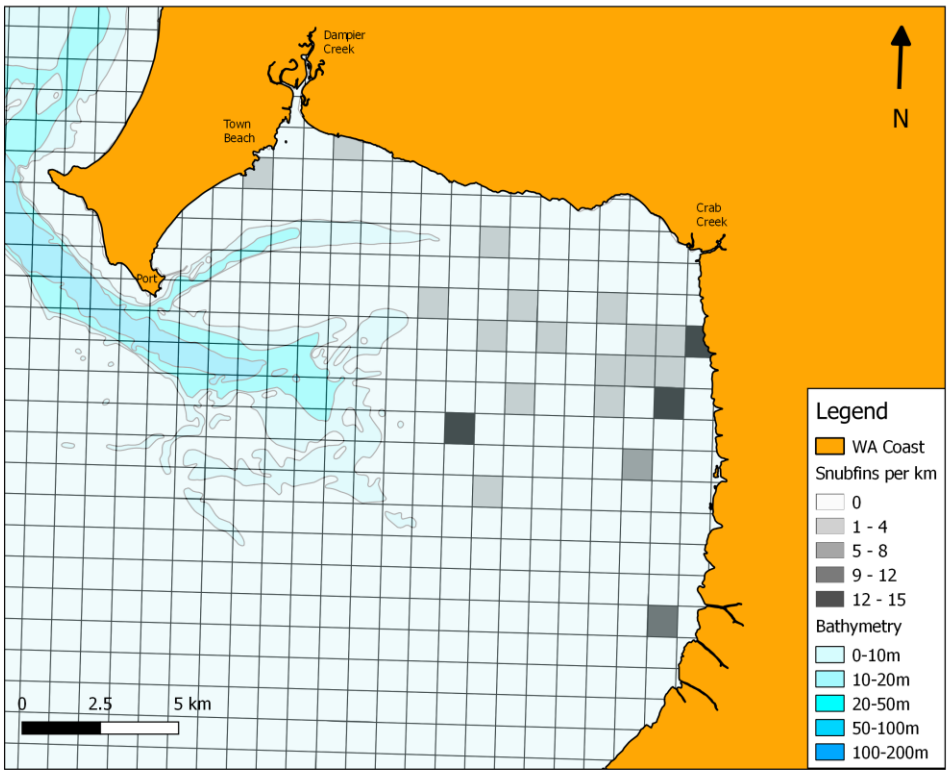

Figure 4- Density of snubfin dolphins (product of total dolphins divided by survey effort per 1km grid cell) across the three day census with bathymetry overlaid.

Identification and resight rates

A total of 96 individual snubfins were directly identified from photo-identification images and were thus present in the Bay during the census. Of the 96 individual snubfins sighted and identified, 28% (27) were resights, meaning they have been sighted in one or more previous surveys of Roebuck Bay. One individual commonly known as 'Grunge' (ID rb025oh) was first sighted on 8th May 2007 and has been resighted multiple times over the following 12 years, most recently during the census with a new calf. A further six animals that were first sighted in 2008 or 2009 have also been sighted on multiple occasions, suggesting they are resident in the area (IDs rb021oh, rb036oh, rb041oh, rb069oh, rb104oh, rb120oh). Similarly, five of the six bottlenose dolphins recorded during the census have been previously reported in the Bay, some since 16 May 2007 (IDs rb027ta, rb040ta and rb045ta) and others in 2013 and 2017 respectively (IDs ta404 and ta411). Of the 96 snubfins

identified 60 (62%) were considered distinctively marked (D1), 20 (21%) subtly marked (D2) and 16 (17%) clean fins (D3).

Table 1 – Resighting history of the 27 individuals that have been previously identified and are in the photo-identification catalogue/Finbook.

ID	First seen	Last seen	# of sightings	# of years sighted
oh301	2/10/2013	5/04/2019	10	3
oh306	2/10/2013	5/04/2019	6	3
oh320	4/10/2013	5/04/2019	3	2
oh324	4/10/2013	6/04/2019	2	2
oh330	5/10/2013	6/04/2019	8	3
oh340	5/10/2013	4/04/2019	19	4
oh365	11/10/2013	6/04/2019	4	3
oh388	20/10/2013	5/04/2019	18	5
oh400	25/10/2013	6/04/2019	11	3
oh406	1/11/2013	4/04/2019	16	4
oh444	16/10/2013	4/04/2019	4	3
rb021oh	30/07/2008	4/04/2019	4	3
rb025oh	8/05/2007	6/04/2019	22	9
rb036oh	30/06/2009	6/04/2019	10	4
rb041oh	30/06/2009	6/04/2019	8	4
rb069oh	19/05/2010	5/04/2019	25	4
rb101oh	25/10/2013	4/04/2019	6	3
rb104oh	10/07/2009	5/04/2019	7	5
rb120oh	1/09/2009	5/04/2019	2	2
rb182oh	6/07/2014	6/04/2019	6	3
rb194oh	23/02/2015	4/04/2019	2	2
rb204oh	29/05/2018	5/04/2019	3	2
rb205oh	29/05/2018	6/04/2018	2	2
rb206oh	29/05/2018	4/04/2019	2	2
rb207oh	29/05/2018	4/04/2019	2	2
rb210oh	29/05/2018	6/04/2018	2	2
rb213oh	29/05/2018	5/04/2018	2	2
rb027ta	16/05/2007	6/04/2018	24	8
rb040ta	16/05/2007	6/04/2018	4	3
rb045ta	16/05/2007	6/04/2018	4	3
ta404	06/10/2013	6/04/2018	13	5
ta411	06/04/2017	6/04/2018	3	3

Community involvement

Three additional snubfin individuals were sighted by the CTO vessels that were not sighted by the DBCA survey vessels. The CTO vessels also sighted and photographed the third species of dolphin

known to inhabit the Bay, humpback dolphin, which was a valuable contribution to the census and for reporting against the target of maintaining species diversity within the marine park.

Discussion

Abundance of dolphins in Roebuck Bay

Snubfin dolphins were the predominant dolphin species sighted during the census. A total of 96 individual snubfin dolphins (including 10 calves) were sighted over the three days (resights excluded). Our direct count is comparable to the number of animals recorded by Brown et al. (2014a) during their month of surveys in October 2013 (100 individuals excluding calves) and in April 2014 (79 individuals excluding calves). The surveys by Brown et al. (2014a) identified 114 individuals (excluding calves) across the two sampling periods and produced a modelled abundance estimate of 130 SE± 11.9 (CI 109-155) for the Roebuck Bay population. This is similar to an earlier estimate from 2009 of 90 SE± 27.95 (95% CI 47-174) (Deb Thiele unpublished data). These surveys identified 97 individuals between May and August 2009 (Deb Thiele unpublished data). These findings indicate that 1) the snubfin population inhabiting Roebuck Bay has remained relatively stable over this time period and 2) that the direct census approach can be reliably used to evaluate the snubfin population in the Bay.

While these different approaches have produced similar results regarding the number of individuals in the Bay at any given time, the mark-recapture (MR) modelling techniques used by Brown and Thiele provides the added advantage of confidence intervals around the abundance estimate. Unlike a direct count which is a single value, MR modelling accounts for the proportion of dolphins that may be missed during a survey and also provides more demographic information such as survival rates and potentially information on emigration rates that a direct count census cannot. These different approaches can be used to answer different management questions, yet both provide suitable information for monitoring the long term health of the dolphin population. Further, two of the key transects (RB1 and RB2) that were used in the census were repeated 3 times over the three day sampling period, which provides data suitable to meet assumptions required for mark-recapture modelling. Thus, if the same sampling design and survey effort used for the census were followed in future years, MR modelling could be used to model population size over the census data from several years.

While the long term goal should be to provide suitable data that can be used in MR modelling, the census approach is still useful for regular assessments to monitor dolphin use of the Bay and to maintain the photo-identification database and individual sighting records.

Two other dolphin species were sighted during the census; bottlenose (six individuals) and humpback dolphins (two individuals; a mother/calf pair). This is consistent with Brown et al. (2014b) who saw mostly small groups of bottlenose dolphins around the 'Inner Anchorage' northern portion of the Bay. These individuals have been resighted over several years and are likely resident to the Bay also. Only a single sighting of fifteen humpback dolphins in the middle/eastern part of the Bay, was reported by Brown et al. (2014b) whereas the mother/calf pair sighted by the CTO vessel in our census was located closer to the township. Humpback dolphins are thought to visit Roebuck Bay but not necessarily reside in the area and likely have home ranges over a wider area than the relatively small study area of the census (Brown et al., 2016).

Distribution of sightings, group size

Most snubfins sighted were in the eastern part of the Bay with some in the Inner Anchorage area (Figure 3). There were fewer sightings in the Inner Anchorage area than in previous surveys (Brown et al., 2014a, Brown et al., 2014b) and this may have been due to more survey effort in this area by Brown et al., (2014a) and the shallow water depths and spring tides reducing the amount of inshore habitat available during the census surveys. Although fewer groups were encountered snubfin group sizes were similar to those reported by Brown et al. 2014a (range 1-16; mean 4.4), with our largest group being 17 and a mean of 3.9.

Encounter rates

Encounter rates were lower than the 0.64 dolphins/km reported by Brown et al. (2016) for the northern transects RB1 and RB2 but comparable to encounter rates for snubfins at other study sites in the Kimberley (Brown et al., 2016). Notably, our census specifically included additional transects in expected low density areas to ensure full coverage of the Bay whereas Brown et al (2014a, 2014b and 2016) concentrated only on higher density areas. For the purposes of this project we did not calculate encounter rate per transect. If habitat use (using transect as a proxy) across the Bay was of interest in future this could be calculated retrospectively.

Identification and resighting rate

The majority (62%) of individual dorsal fins were distinctively marked with much fewer subtly marked (21%) and clean fins (17%). The dolphin population inhabiting Roebuck Bay is known to have a high proportion of marked individuals, therefore the total number of marked individuals resulting from this census should be representative of most of the population, regardless of the small number of clean fins encountered. Many of the clean fins encountered had secondary marks such as rake marks that allowed us to differentiate them from other individuals but these markings will not persist long term and therefore they will not be added to the photo-catalogue.

It is possible that some of the clean fins were sighted across multiple days and therefore the census value may be slightly inflated but given that most of the dorsal fins were marked the minimum direct count would be 80 individuals. Approximately a third (28%) of all snubfins sighted during the census were resights from previous surveys. Some dorsal fins have remained relatively stable over a long time period (up to 10 years) whilst others have been substantially modified (Appendix 1). Modifications to dorsal fins (termed 'evolving natural tags') are expected, particularly in a population that has a high proportion of marked individuals as new scars are acquired over time. Brown et al. (2016) estimated that 89% of the population were distinctively marked and (Smith et al., 2018) further noted that 62% of snubfins in Roebuck Bay exhibit shark bite scarring. While the high rate of scarring is an advantage to being able to identify individuals, the implications from the rate at which scarring occurs means that it may be challenging to build up long term sighting histories of individuals that would reveal life history information such as calving rate, associates and potentially life span, because as the dorsal fins are substantially modified over time the original identity of that individual would be unknown. This also means that there are many individuals in the population that, although may be resighted, cannot be matched to the existing photo-identification catalogue and will therefore be given a new identification code and added to the catalogue again. Therefore, the photo-identification catalogue may become outdated quite quickly and also contain many more images and ID codes than is representative of the population as some individuals will receive multiple ID codes over their life time. Misidentification of individuals will bias mark-recapture abundance estimates but as the census is a snapshot in time then this should be relatively unaffected by these evolving natural tags.

Conservation and management implications

Snubfin dolphins are recognised as vulnerable by the IUCN at a species level (Parra et al., 2017) but at a local scale, snubfins are considered to be relatively abundant in Roebuck Bay (Brown et al., 2016). This has implications for conservation and management of the species as the Roebuck Bay population may provide a stronghold for the species in Western Australia. Snubfins are also valued locally by the community and identified as a key value in the Yawuru Nagulagan/ Roebuck Bay Marine Park (Department of Parks and Wildlife, 2016).

Recommendations for future research

This census demonstrates that a rapid population census done with high intensity survey effort over a short period (days) may be appropriate in monitoring trends in abundance of the population over time (years). Whilst censes do not have the power to detect subtle changes in abundance as mark-recapture do, a census is adequate to detect a major decline (in the order of tens of individuals). We recommend that the survey is repeated every 2-3 years (maximum 5 yearly) to ensure that management actions and causal effects could be investigated over a suitable time frame if a decline was detected. The census needs to be conducted at the same time of year to make the results comparable between years. The timing / season for a future census has not been decided and would need to be discussed and chosen with joint managers input.

Other research interests include understanding habitat use by snubfin dolphins and seasonality of their movements in and around the Bay. Data on these knowledge gaps would help inform management of activities such as fishing and boat traffic in the Marine Park. As recommended in Brown et al. (2014b) lower intensity survey effort more regularly throughout the year would reveal more about habitat use, home ranges and movement patterns. Dolphin Watch volunteers that have been trained in the Dolphin Watch app could contribute valuable data, particularly if they contribute high resolution dorsal fin photos, in this regard to complement the periodic high intensity surveys.

Ethics statement

We operated under a permit from the Department of Primary Industries and Regional Development U10/2019 for the project 2018-30B Habitat use, distribution and abundance of coastal dolphin species that was assessed and approved by the Department of Biodiversity, Conservation and Attractions Animal Ethics Committee and the Department of Biodiversity, Conservation and Attractions Scientific licence SC001528. The surveys were conducted with joint management partners Nyamba Buru Yawuru Pty Ltd. (NBY) and country managers participating in the survey.

Acknowledgements

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partnership with Nyamba Buru Yawuru Pty Ltd country managers under the joint management arrangement of Yawuru Nagulagan Roebuck Bay Marine Park. We acknowledge the Yawuru traditional owners past, present and emerging and it is an honour to work with Yawuru people on their sea country.

Snubfin census participants included

DBCA
Augustine Badal (Augie) Nyangumarta Ranger
Peter Carstairs (Wildlife Officer)
Ellen D'Cruz (Technical Officer)
Corrine Douglas (Technical Officer)
Nathan Hunter (Nyangumarta Ranger)
Jason Menzies (Community Involvement Unit Manager)
Jesse Murdoch (A/Yawuru Communications Officer)
Chris Nutt (Yawuru Marine Park Coordinator)
Luke Puertollano (Trainee Yawuru Supervisor)
Holly Raudino (Research Scientist)
Anthony Richardson (Senior Yawuru Marine Ranger)
Chloe Rings Nyangumarta (Ranger Supervisor)
Kelly Waples (Principal Research Scientist)
Jutta Wildforster (Marine Operations Officer Licensing)

Nyamba Buru Yawuru Pty Ltd. (NBY)
Johani Mamid
Eduardo Maher
Pius Gregory
Ronald Wade

DoT & TAMS
Skippers

Registered and trained dolphin watchers
Kevin Smith
Karis Erceg
Ingrid de Meillon
Case van Dommele
Paul Kelly
Deb Turner
Luke Turner
Jake Turner
Mary Blackburn
Tia Markham
Jemma Norton
Sandy Passmore
Irene Huang
Perry Benjamin
Maryann Walley
Connie Trohamm
Emma Winter
Shane Baugh

Andrew Close
Sam Wasson
Glen Weston
Sarah Tobias
Adam Flinn
Johani Mamid
Dianne Bennett
Tiana Jones

Literature Cited

BROWN, A. M., BEJDER, L., POLLOCK, K. H. & ALLEN, S. J. 2014a. Abundance of coastal dolphins in Roebuck Bay, Western Australia. Murdoch University: Report to WWF-Australia.

BROWN, A. M., BEJDER, L., POLLOCK, K. H. & ALLEN, S. J. 2014b. Abundance of coastal dolphins in Roebuck Bay, Western Australia: Updated results from 2013 and 2014 sampling periods. . Western Australia: Report to WWF-Australia.

BROWN, A. M., BEJDER, L., POLLOCK, K. H. & ALLEN, S. J. 2016. Site-Specific Assessments of the Abundance of Three Inshore Dolphin Species to Inform Conservation and Management. *Frontiers in Marine Science,* 3**,** doi: 10.3389/fmars.2016.00004.

DEPARTMENT OF PARKS AND WILDLIFE 2016. Yawuru Nagulagun / Roebuck Bay Marine Park Joint Management Plan 86. *In:* WILDLIFE, D. O. P. A. (ed.). Perth.

PARRA, G., CAGNAZZI, D. & BEASLEY, I. 2017. *Orcaella heinsohni. The IUCN Red List of Threatened Species 2017 e.T136315A50385982* [Online]. [Accessed Downloaded on 11 January 2018].

PARRA, G. J. 2006. Resource partitioning in sympatric delphinids: space use and habitat preferences of Australian snubfin and Indo-Pacific humpback dolphins. *Journal of Animal Ecology,* 75**,** 862-874.

SMITH, F., ALLEN, S. J., BEJDER, L. & BROWN, A. M. 2018. Shark bite injuries on three inshore dolphin species in tropical northwestern Australia. *Marine Mammal Science,* 34**,** 87-99.

Appendix 1 – Examples of dorsal fin marks that are stable and A) subtly marked & B) distinctively marked and those modified over time substantially C) and subtly D) & E).