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# Short Note

# Dusky Dolphin (*Lagenorhynchus obscurus*) Mother–Calf Pairs: An Aerial Perspective

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In the 35 years that dusky dolphins (*Lagenorhynchus obscurus*) have been studied off Kaikoura, New Zealand, there has been shore-, boat-, and acoustic-based research on their movements and behavioural ecology (Würsig et al., 1997, 2007). While boat-based research has provided important insights into the overall fission-fusion societies of dusky dolphins off Kaikoura (Orbach et al., 2018, this issue) and nursery group habitat use (Weir et al., 2008, 2010; Deutsch et al., 2014), there have been limitations to individual focal follows, particularly of mothers with calves within large pods. Only 52% of dusky dolphins are estimated to have distinguishable natural markings on their dorsal fins (Kügler & Orbach, 2014), limiting the number of individuals that can be positively identified and followed from a boat-based platform. As a result, we searched for new and cost-effective ways to study dolphin behaviours, spacings, and interactions. Lightweight, unmanned aerial vehicles (UAVs) are proving to be the better research platforms for gathering information on dusky dolphin behaviour, within-group spacing, and inter-individual interactions as compared with low vantage point observations from a small vessel.

In the past decade, UAVs have revolutionized how wildlife can be observed and studied. Coastal applications of UAVs have proved useful for counting seabirds (Perryman et al., 2014; Hodgson et al., 2016) and sea turtles (Rees et al., 2018). UAV operations are becoming more common for marine mammal research due to increasing affordability, longer in-air times, larger ranges, and potentially less disturbance than other research methods due to associated noise compared to traditional aerial research methods, including helicopters and fixed wing aircrafts (Koski et al., 2015; Fiori et al., 2017). Additionally, UAVs offer opportunities to observe areas with limited access by foot or vessel—for example, UAVs have enabled spotted (*Phoca largha*) and ribbon (*Histriophoca fasciata*) seal counts in the Bering Sea pack ice (Moreland et al., 2015); gray seal (*Halichoerus grypus*) counts within breeding colonies in eastern Canada (Seymour et al., 2017); gray and harbor seal (*Phoca vitulina*) abundance estimates, age classification, and individual identification (Pomeroy et al., 2015); and Steller sea lion (*Eumetopias jubatus*) individual identification in Alaska (Sweeney et al., 2016). UAVs have also been used to survey dugongs (*Dugong dugon*) (Hodgson et al., 2013) and humpback whales (*Megaptera novaeangliae*) in Australia (Hodgson et al., 2017); collect identification-quality images of bowhead whales (*Balaena mysticetus*) near Igloolik, Nunavut (Koski et al., 2015); measure the surface area of humpback whale females and calves to compare body condition at a breeding area in Australia (Christiansen et al., 2016b); and measure body lengths of southern right whales (*Eubalaena australis*) off New Zealand's Auckland Islands (Dawson et al., 2017).

Our objective was to determine if it was possible to ascertain behaviours of mothers and calves within nursery groups and within large groups using a UAV that provided vertical, low-altitude video recordings. Specifically, we sought to determine swimming speed, inter-adult distance, and respiration and suckling rates for dusky dolphin mothers and calves. The results presented herein provide examples of the types of information that can be gathered using these new techniques.

Kaikoura is located on the east coast of the South Island of New Zealand (42.30° S, 173.32° E). Field work occurred within the open-ocean embayment (covering approximately 100 $km^2$ in area) between the Kaikoura Peninsula and Haumuri Bluffs in December 2017. The area is characterized by a nearshore submarine canyon off Goose Bay and reaches depths of over 1,400 m (Lewis & Barnes, 1999). Dolphin groups were located visually and approached in a 6-m rigid-hull inflatable. In adherence with New Zealand's Marine Mammals Protection Act of 1978 and Marine Mammals Protection Regulations of 1992, we maintained no wake or idle speeds when within 300 m of dolphins and never approached dolphin groups if there were three or more vessels already operating within 300 m of the group.

All focal group follows were conducted using Vertical Take-Off and Landing (VTOL) UAV operations (UAV hereafter). Flights took place only in Visual Meteorological Conditions (VMC)—that is, 10 km sky line of sight, clear of clouds at the maximum legal flight altitude (122 m), and no rain—and 10 kts maximum wind speed (Civil Aviation Authority of New Zealand, 2018). The UAV was a Phantom 4TM (DJI Innovations, Shenzhen, China), with a four-rotor helicopter (1.38 kg; diameter: 35 cm engine-to-engine). The built-in camera was fitted with a polarized filter. DJI Li-Po batteries (4 S, 5,870 mAh) ensured a maximum flight time of 25 min, although actual flight time tended to be slightly less than this value. The UAV was launched and retrieved manually with the bow oriented downwind and the outboard motor disengaged. After launching the UAV, the vessel was not required to be near the dolphins, and so it generally kept at least 50 m from mother–calf pairs and 20 m or higher Above Sea Level (ASL) to eliminate vessel and UAV proximity on behaviours.

Video was analyzed using a VLC media player by an experienced observer. Every 30 s, the observer paused the video and recorded the GPS position of the UAV (from the UAV metadata on the screen); the number of mothers (adults with a calf, usually in echelon or infant position), calves (less than two thirds the length of the adult), and other individuals in the frame; and the distances (number of mother body lengths, with a mother body length considered as approximately 1.8 m according to Cipriano [1992]) between each mother in view and her nearest adult (similar size to mother) neighbour. The observer subsequently reviewed the same videos to follow each mother–calf pair, reviewing several times if multiple mother–calf pairs were captured in the frame. Counts were recorded each time the focal mother or calf took a breath and each time the calf initiated a suckling position (infant rolls to one side and directs rostrum under mother in location of mammary slits). The focal follow ended when the mother–calf pair left the frame of view or if visibility deteriorated (due to glare or the height of the UAV) and follows of mother–calf pairs were no longer possible. The process was repeated until all mother–calf pairs in the video had been tracked and annotated.

Positional information and time were used to calculate the dolphin swimming speed for each 30 s segment and for the entire video session. Data for inter-adult spacing were pooled for each group and divided by the number of minutes and the number of mothers in view. For each video, total number of breaths for mothers and calves were pooled, respectively, and were scaled by the total number of minutes that mothers and calves were in view for all focal follows. Similarly, for each video, the total number of suckling bouts were pooled and divided by the total number of minutes calves were in view for all focal follows.

From 2 to 11 December 2017, four nursery groups and seven large groups with mother–calf pairs were video-recorded (19 videos of approximately 20 min each) and analyzed. Mean swimming speed for mothers and calves was 4.65 ± 2.41 $km/h^{-1}$ and mean inter-adult spacing was 1.66 ± 2.1 body lengths (see Figure 1a & b). Mean respiration rate for mothers and calves was 2.81 ± 0.12 and 3.58 ± 0.15 $breaths/min^{-1}$, respectively, and suckling rate was 0.65 suckling $attempts/min^{-1}$.

Through this study, we were able to determine swimming speed, inter-adult spacing, and respiration and suckling rates for dusky dolphin mothers and calves. Respiration rates of adult female dusky dolphins in our study (2.81 $breaths/min^{-1}$) were similar to those of dusky dolphins along the coast of Patagonia, Argentina (2.9 $breaths/min^{-1}$), that were determined using radio tracking (Würsig, 1982). The swimming speeds reported herein were also similar to those reported by Würsig & Würsig (1980) using theodolite readings, and to those reported by Srinivasan & Markowitz (2010) from a boat-based platform. These similarities suggest that the UAV operations described herein can provide accurate measures of swimming speeds and respiration rates for dusky dolphins. In the present study, we were also able to determine the respiration and suckling rates for dusky dolphin calves, something that has not been feasible by other observation methods to date.

UAV operations allowed us to view dusky dolphin mothers and calves from a novel perspective. Using the UAV likely caused little to no disturbance to the focal dolphins, whereas vessels have been shown to affect the behaviours of mother–calf pairs of bottlenose dolphins (*Tursiops* *truncatus*) (Guerra et al., 2014), as well as the behaviours of large groups of dusky dolphins (Lundquist et al., 2012, 2013). Some studies have shown that a UAV can reduce or eliminate visible disturbance compared to traditionally used methods. For example, there were lower proportional

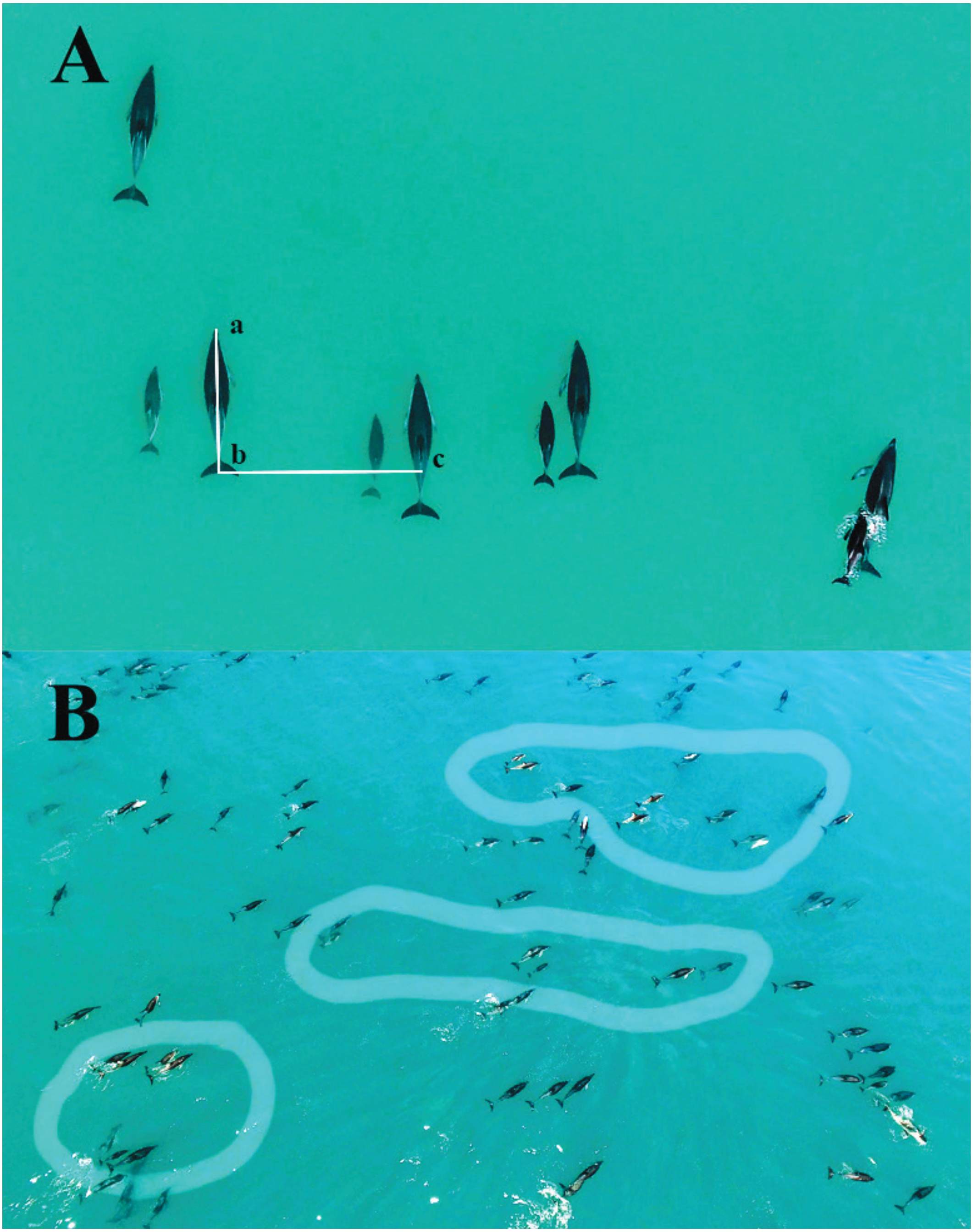


**Figure 1.** (A) Four mother–calf pairs and a fifth adult without calf travelling as a nursery group separate from the large group; letters a and b represent one adult body length, and letters b and c show a mother–mother distance of 1.41 body lengths. (B) Mothers and calves throughout a part of the large group; several mother–calf pairs are circled for ease of viewing.

disturbance levels to spotted and ribbon seals when a UAV was employed than when a helicopter was used (Moreland et al., 2015). The behavioural ecology of the animal under study must be considered as some species are targeted by aerial predators (Borelle & Fletcher, 2017). However, as dolphins have no aerial predators, and UAV noise is similar to ambient noise and usually outside the hearing thresholds of odontocetes (Christiansen et al., 2016a), disturbance is expected to be minimal, if at all. Even though behavioural responses to the UAV were not observed, we cannot rule out the presence of physiological changes such as the elevated heart rate exhibited by black bears (*Ursus americanus*) in response to UAV flights despite no observable behavioural responses (Ditmer et al., 2015). Overall, the use of a UAV allowed us to make observations that were not previously possible and revealed more details of the behaviours of dusky dolphin mothers and calves.

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## Literature Cited

Borelle, S. B., & Fletcher, A. T. (2017). Will drones reduce investigator disturbance to surface-nesting birds? *Marine Ornithology*, *45*, 89-94.

Christiansen, F., Rojano-Doñate, L., Madsen, P. T., & Bejder, L. (2016a). Noise levels of multi-rotor unmanned aerial vehicles with implications for potential underwater impacts on marine mammals. *Frontiers in Marine Science*, *3*, 277. https://doi.org/10.3389/fmars.2016.00277

Christiansen, F., Dujon, A. M., Sprogis, K. R., Arnould, J. P. Y., & Bejder, L. (2016b). Noninvasive unmanned aerial vehicle provides estimates of the energetic cost of reproduction in humpback whales. *Ecosphere*, *7*(10), e01468. https://doi.org/10.1002/ecs2.1468

Cipriano, F. W. (1992). *Behavior and occurrence patterns, feeding ecology, and life history of dusky dolphins (*Lagenorhynchus obscurus*) off Kaikoura, New Zealand* (Unpublished doctoral dissertation). University of Arizona, Tucson.

Civil Aviation Authority of New Zealand. (2018). Retrieved from https://www.caa.govt.nz

Dawson, S. M., Bowman, M. H., Leunissen, E., & Sirguey, P. (2017). Inexpensive aerial photogrammetry for studies of whales and large marine animals. *Frontiers in Marine Science*, *4*, 366. https://doi.org/10.3389/fmars.2017.00366

Deutsch, S., Pearson, H., & Würsig, B. (2014). Development of leaps in dusky dolphin (*Lagenorhynchus obscurus*) calves. *Behaviour*, *151*, 1555-1577. https://doi.org/10.1163/1568539X-00003200

Ditmer, M. A., Vincent, J. B., Werden, L. K., Tanner, J. C., Laske, T. G., Iaizzo, P. A., . . . Fieberg, J. R. (2015). Bears show a physiological but limited behavioural responses to unmanned aerial vehicles. *Current Biology*, *25*, 1-6. https://doi.org/10.1016/j.cub.2015.07.024

Fiori, L., Doshi, A., Martinez, E., Orams, M. B., & Bollard-Breen, B. (2017). The use of unmanned aerial systems in marine mammal research. *Remote Sensing*, *9*(6), 543. https://doi.org/10.3390/rs9060543

Guerra, M., Dawson, S. M., Brough, T. E., & Rayment, W. J. (2014). Effects of boats on the surface and acoustic behaviour of an endangered population of bottlenose dolphins. *Endangered Species Research*, *24*, 221-236. https://doi.org/10.3354/esr00598

Hodgson, A., Kelly, N., & Peel, D. (2013). Unmanned aerial vehicles (UAVs) for surveying marine fauna: A dugong case study. *PLOS ONE*, *8*(11), e79556. https://doi.org/10.1371/journal.pone.0079556

Hodgson, A., Peel, D., & Kelly, N. (2017). Unmanned aerial vehicles for surveying marine fauna: Assessing detection probability. *Ecological Applications*, *27*(4), 1253-1267. https://doi.org/10.1002/eap.1519

Hodgson, J. C., Baylis, S. M., Mott, R., Herrod, A., & Clarke, R. (2016). Precision wildlife monitoring using unmanned aerial vehicles. *Nature Scientific Reports*, *6*, 22574. https://doi.org/10.1038/srep22574

Koski, W. R., Gamage, G., Davis, A. R., Mathews, T., LeBlanc, B., & Ferguson, S. (2015). Evaluation of UAS for photographic re-identification of bowhead whales, *Balaena mysticetus*. *Journal of Unmanned Vehicle Systems*, *3*(1), 22-29. https://doi.org/10.1139/juvs-2014-0014

Kügler, A., & Orbach, D. N. (2014). Sources of notch and scar patterns on the dorsal fins of dusky dolphins (*Lagenorhynchus obscurus*). *Aquatic Mammals*, *40*(3), 152-165. https://doi.org/10.1578/AM.40.3.2014.152

Lewis, K. B., & Barnes, P. M. (1999). Kaikoura Canyon, New Zealand: Active conduit from near-shore sediment zones to trench-axis channel. *Marine Geology*, *162*, 39-69. https://doi.org/10.1016/S0025-3227(99)00075-4

Lundquist, D., Gemmell, N. J., & Würsig, B. (2012). Behavioural responses of dusky dolphin groups (*Lagenorhynchus obscurus*) to tour vessels off Kaikoura, New Zealand. *PLOS ONE*, *7*(7), e41969. https://doi.org/10.1371/journal.pone.0041969

Lundquist, D., Gemmell, N. J., Würsig, B., & Markowitz, T. (2013). Dusky dolphin movement patterns: Short-term effects of tourism. *New Zealand Journal of Marine and Freshwater Research*, *47*(4), 430-449. https://doi.org/10.1080/00288330.2013.778301

Moreland, E. E., Cameron, M. F., Angliss, R. P., & Boveng, P. L. (2015). Evaluation of a ship-based unoccupied aircraft system (UAS) for surveys of spotted and ribbon seals in the Bering Sea pack ice. *Journal of Unmanned Vehicle Systems*, *3*(3), 114-122. https://doi.org/10.1139/juvs-2015-0012

Orbach, D. N., Pearson, H. C., Beier-Engelhaupt, A., Deutsch, S., Srinivasan, M., Weir, J. S., . . . Würsig, B. (2018). Long-term assessment of spatio-temporal association patterns of dusky dolphins (*Lagenorhynchus obscurus*) off Kaikoura, New Zealand. *Aquatic Mammals*, *44*(6), 608-619. https://doi.org/10.1578/AM.44.6.2018.608

Perryman, W., Goebel, M., Ash, N., LeRoi, D., & Gardner, S. (2014). Small unmanned aerial systems for estimating abundance of krill-dependent predators: A feasibility study with preliminary results. In J. Walsh (Ed.), *AMLR 2010/11 field season report, U.S. Antarctic Marine Living Resources Program* (NOAA-TM-NMFS-SWFSC-524, pp. 64-72). La Jolla, CA: National Marine Fisheries Service.

Pomeroy, P., O'Connor, L., & Davies, P. (2015). Assessing use of and reaction to unmanned aerial systems in gray and harbor seals during breeding and molt in the UK. *Journal of Unmanned Vehicle Systems*, *3*(3), 102-113. https://doi.org/10.1139/juvs-2015-0013

Rees, A. F., Avens, L., Ballorain, K., Bevan, E., Broderick, A. C., Carthy, R. R., . . . Godley, B. J. (2018). The potential of unmanned aerial systems for sea turtle research and conservation: A review and future directions. *Endangered Species Research*, *35*, 81-100. https://doi.org/10.3354/esr00877

Seymour, A. C., Dale, J., Hammill, M., Halpin, P. N., & Johnstone, D. W. (2017). Automated detection and enumeration of marine wildlife using unmanned aircraft systems (UAS) and thermal imagery. *Nature Scientific Reports*, *7*, 45127. https://doi.org/10.1038/srep45127

Srinivasan, M., & Markowitz, T. M. (2010). Predator threats and dusky dolphin survival strategies. In B. Würsig & M. Würsig (Eds.), *The dusky dolphin: Master acrobat off different shores* (pp. 133-150). Amsterdam, The Netherlands: Academic Press. https://doi.org/10.1016/B978-0-12-373723-6.00007-2

Sweeney, K. I., Helker, V. T., Perryman, W. I., LeRoi, D. J., Fritz, L. W., Gelatt, T. S., & Angliss, R. P. (2016). Flying beneath the clouds at the edge of the world: Using a hexacopter to supplement abundance surveys of Steller sea lions (*Eumetopias jubatus*) in Alaska. *Journal of Unmanned Vehicle Systems*, *4*(1), 70-81. https://doi.org/10.1139/juvs-2015-0010

Weir, J. S., Deutsch, S., & Pearson, H. C. (2010). Dusky dolphin calf rearing. In B. Würsig & M. Würsig (Eds.), *The dusky dolphin: Master acrobat off different shores* (pp. 177-193). Amsterdam, The Netherlands: Academic Press.

Weir, J. S., Duprey, N. M. T., & Würsig, B. (2008). Dusky dolphin (*Lagenorhynchus obscurus*) subgroup distribution: Are shallow waters a refuge for nursery groups? *Canadian Journal of Zoology*, *86*(11), 1225-1234. https://doi.org/10.1139/Z08-101

Würsig, B. (1982). Radio tracking dusky porpoise in the South Atlantic. *Mammals in the Seas* (FAO Fisheries Series No. 5), *4*, 145-160.

Würsig, B., & Würsig, M. (1980). Behaviour and ecology of the dusky dolphin, *Lagenorhynchus obscurus*, in the South Atlantic. *Fishery Bulletin*, *77*(4), 871-890.

Würsig, B., Duprey, N., & Weir, J. (2007). *Dusky dolphins (*Lagenorhynchus obscurus*) off Kaikoura, New Zealand: Present knowledge and goals for the future* (DOC Science and Technical Publications, Research and Development Series 270). Wellington, New Zealand: Department of Conservation. 28 pp.

Würsig, B., Cipriano, F., Slooten, E., Constantine, R., Barr, K., & Yin, S. (1997). Dusky dolphins (*Lagenorhynchus obscurus*) off New Zealand: Status of present knowledge. *Report of the International Whaling Commission*, *77*, 871-890.