Aquatic Mammals 2022, *48*(2), 126-131, DOI 10.1578/AM.48.2.2022.126

Short Note

Natural Barrier Feeding Technique in *Megaptera novaeangliae* in Central Coastal Area of Golfo San Jorge, Patagonia, Argentina

Marina Griselda Riera,[1] Daniel Lucchetti,[2] and Mariano A. Coscarella[3,4]

[1]*Facultad de Ciencias Naturales y Ciencias de la Salud, Universidad Nacional de la Patagonia San Juan Bosco, Comodoro Rivadavia, Argentina*
[2]*Área Natural Protegida Punta Marqués, Rada Tilly, Argentina*
[3]*Facultad de Ciencias Naturales y Ciencias de la Salud, Universidad Nacional de la Patagonia San Juan Bosco, Puerto Madryn, Argentina*
[4]*Laboratorio de Mamíferos Marinos (LAMAMA), Centro para el Estudio de Sistemas Marinos (CESIMAR—CCT CENPAT-CONICET), Puerto Madryn, Argentina*
E-mail: mcoscarella@cenpat-conicet.gob.ar

Humpback whales (*Megaptera novaeangliae*) are cosmopolitan and highly migratory animals. They are found in all ocean basins and annually migrate between low-latitude waters, where they breed and calve during the winter and spring, and high-latitude waters, where they feed during the summer and autumn (Dawbin, 1966; Clapham, 2000; Cypriano-Souza et al., 2010; Bortolotto et al., 2016a).

Commercial whaling resulted in a considerable reduction in all humpback whale populations. In the Southern Hemisphere alone, more than 200,000 whales were caught (Zerbini et al., 2011; Bortolotto et al., 2016a). Most populations, including the Western South Atlantic Ocean Breeding Stock "A" (BSA), have shown signs of recovery after the International Whaling Commission (IWC) enacted a moratorium in the late 1960s (IWC, 1998; Ward et al., 2011; Bortolotto et al., 2016a).

The BSA humpback whale population breeds on the Brazilian coast from Natal (4° S) to Cabo Frio (23° S), while this stock's feeding grounds are off South Georgia and the South Sandwich Islands (Zerbini et al., 2006; Bortolotto et al., 2016a). Information on the migration path indicates that BSA directly head to the feeding grounds from the breeding area (Zerbini et al., 2006). Nevertheless, there is no information about the route the whales take between the feeding and breeding areas.

Along the Argentine coast, the number of sightings and stranded humpback whales has increased in the last decade, probably due to the BSA population increase (Bortolotto et al., 2016b; Dellabianca & Gribaudo, 2019). Humpback whale presence has increased in the last 10 years in the central area of Golfo San Jorge (Patagonia, Argentina), especially during summer and autumn months. Many observations of humpback whales in this area include feeding behaviors that have been reported since 2016. Bortolotto et al. (2016a) reported individuals feeding beyond their frequent feeding areas during migration. Also, growing evidence of humpback whales feeding during typical migration months has been reported for non-migrant individuals (Findlay et al., 2017).

Humpback whales display a wide variety of feeding techniques depending on the site, prey species, and prey density. These techniques include *lunge-feeding* (Jurasz & Jurasz, 1979), *bubblenet-feeding* (Jurasz & Jurasz, 1979; Hain et al., 1982), *flick-feeding* (Jurasz & Jurasz, 1979), *lobtail-feeding* (Weinrich et al., 1992), and *bottom-feeding* (Hain et al., 1995), and three more recent techniques: *single straight-line bubble curtain* (Acevedo et al., 2011, 2017), *pectoral herding* (Kosma et al., 2019), and *trap-feeding* (McMillan et al., 2019). Chenoweth et al. (2017) reported humpback whales feeding on a new prey species—juvenile salmon (Salmonidae) in Alaska—using a variety of techniques, including the use of several barriers, the shoreline being one of the most frequent.

Herein, we describe for the first time a *natural barrier feeding* technique used by several individual whales during feeding bouts on small fishes near the shoreline, which was recorded along the coast of Patagonia, Argentina. The observations took place near Punta Marqués (45° 57' 32.16" S, 67° 32' 33.70" W), a small coastal protected area located near Rada Tilly, in the central coastal area of Golfo San Jorge (Figure 1). Observations were made from a clifftop 160 m high. On 25 March 2016, an adult individual was recorded on video

(using a Nikon P510 camera [Nikon, Tokyo, Japan] mounted on a tripod). We also used footage and still frames from video recorded with an unmanned aerial vehicle (UAV, Mavick Pro; DJI, Shenzhen, China) since 2019. Drone flights were done at heights varying from 10 to 20 m following the whale's path whenever possible. Drone footage of a juvenile that remained in the area for 10 days was captured between 25 May and 4 June 2019. Also, on 4 June 2019, an adult was recorded with the drone. (The supplemental video for this short note is available in the "Supplemental Material" section of the *Aquatic Mammals* website: https://www.aquaticmammals journal.org/index.php?option=com_content&view=article&id=10&Itemid=147.)

The feeding technique described herein, natural barrier feeding, consists of the whale forcing prey against a barrier (a wave-cut platform) and then accelerating towards the prey using, generally, a lateral lunge-feeding approach to capture small fishes. Usually, the feeding events took place at very close range from the coast (between 3 and 20 m away) in shallow waters (3 to 5 m depth). Figure 2 shows the feeding event pattern recorded during a feeding bout on 1 June 2019. The documented feeding event began when the whale approached the coastline (Figure 2A & B) and swam parallel to the shoreline through a school of silversides (probably *Sorgentinia incisa*), forcing the fish to pack closer to the barrier. At an estimated distance of 10 m from the rocks, the whale lunged towards the barrier, opening its mouth and engulfing the prey (Figure 2C-E). Afterwards, the whale swam away from the coast, between 20 and 50 m (Figure 2F), and began a new feeding event, heading again towards the shoreline (Figure 2 G-H).

From drone footage, we recorded whether a feeding event was performed towards the rocks or in the opposite direction; data were analyzed with a Chi-squared test (Zar, 1996). We were able to record 49 feeding bouts (a typical bout track is shown in Figure 3). We analysed 131 feeding events near the barrier and recorded whether feeding was performed in the direction of the platform, away from the platform, or as not possible to determine due to the relative position of the drone. In analyzing the feeding bouts of two individual whales, 64 feeding events could not be classified; of the remaining 67, 64 were made in the direction of the platform, and only three were made in the opposite direction. The feeding events were performed significantly more often while whales were swimming towards the platform ($\chi^2_{1;1;0.05}$; $p = 0.00$).

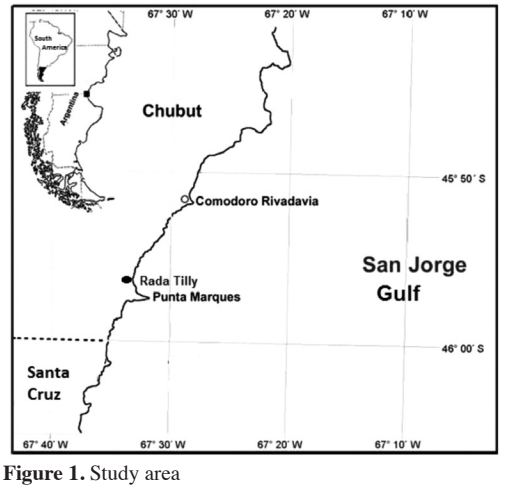

Figure 1. Study area

This short note is the first presentation of this natural barrier feeding behavior for humpback whales. Although barrier feeding using the shoreline was previously mentioned by Chenoweth et al. (2017), these authors did not provide a description of the behavior. Nevertheless, Chenoweth et al. noted that whales used natural and artificial barriers, including the shoreline, and it is possible that the feeding behavior they noted is similar to the one described herein. Considering the number of feeding behaviors previously described for this species elsewhere, humpback whales are highly flexible in how they catch their prey, adapting a basic hunting technique to various environments and prey. According to Hain et al. (1982), a humpback whale generally repeats a fairly rigid feeding pattern over a period of time; however, several humpback individuals or groups feeding in the same area may not display the same feeding strategy.

The described behavior in this short note provides insights on two aspects of feeding behavior for this species: (1) it supports the species' behavioral flexibility and (2) it confirms that this species is in the Southwestern Atlantic feeding in low latitude waters. These observations were only possible because of new technologies (e.g., UAVs) that are proving to be extremely useful for unravelling never before seen behaviors of marine mammals, especially large whales (Christiansen et al., 2016; Dawson et al., 2017; Fiori et al., 2020). This type of footage provides us with new information necessary for more accurate interpretations of marine mammal foraging tactics (Kosma et al., 2019).

Feeding techniques used by humpback whales vary depending on the kind and quantity of food available (Jurasz & Jurasz, 1979; Eisenmann et al., 2016). These new strategies can then be transferred to other individuals within the population, a process that can occur through social or asocial learning (Weinrich et al., 1992; Helweg et al., 2005; McMillan et al., 2019). Cultural transmission, the social learning of information, is believed to occur in several groups of animals, including primates, cetaceans, and birds

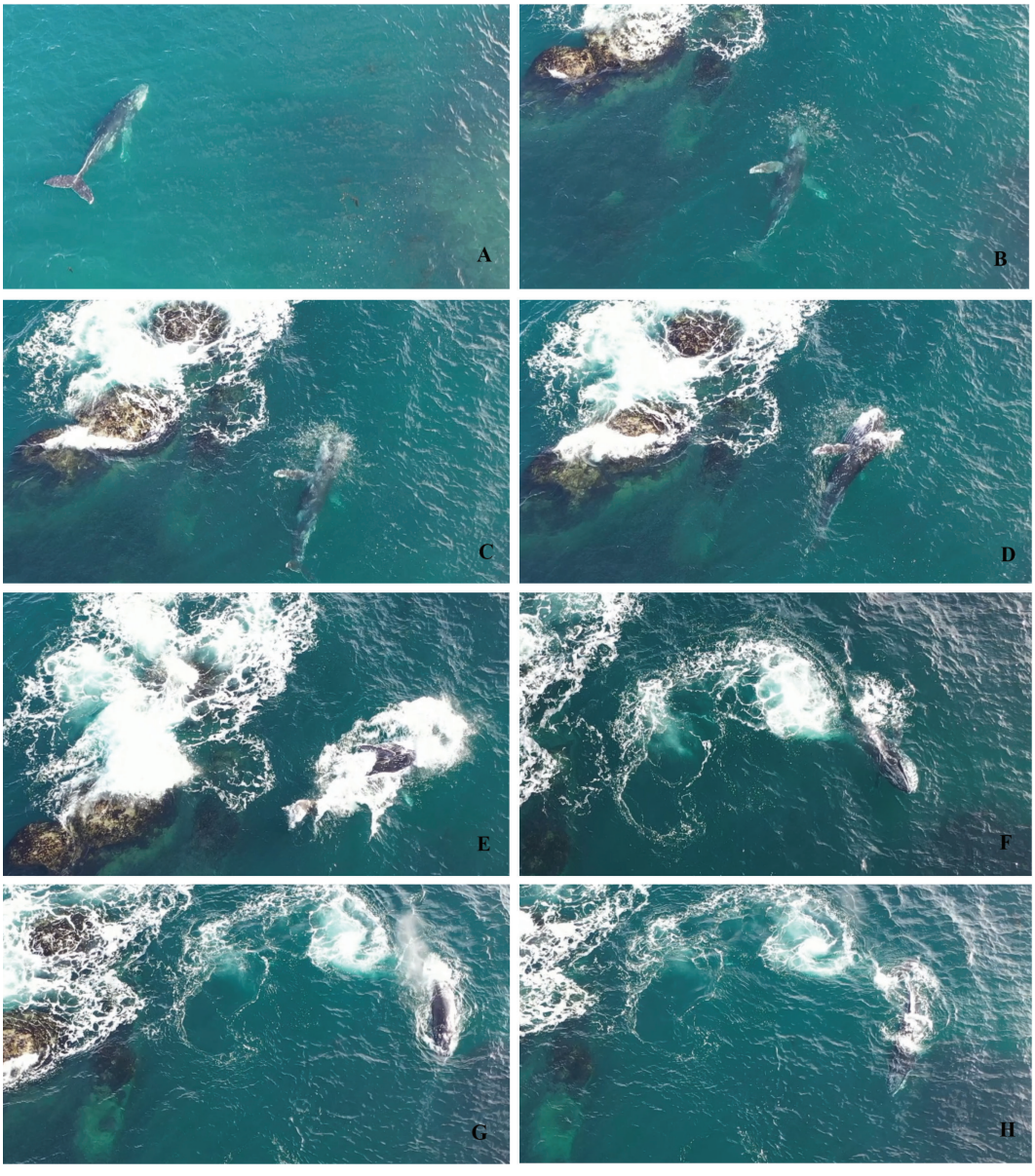

Figure 2. Feeding sequence by a humpback whale (*Megaptera novaeangliae*) using a natural barrier: (A) whale swimming towards the barrier and corralling prey; (B) whale accelerating towards the barrier; (C) whale close to the barrier, with silversides observed out of the water; (D) whale engulfing the prey in the direction of the barrier; (E) whale swimming away from the coast; (F) whale turning in the opposite direction; and (G-H) end of the feeding event, swimming away.

(Brakes et al., 2021). Cultural traits can be passed vertically (from parents to offspring), obliquely (from the previous generation via a nonparent model to younger individuals), or horizontally (between unrelated individuals from similar age classes or within generations) (Whitehead et al., 2004; Herzing, 2005; Garland et al., 2011; Whitehead & Rendell, 2014; Brakes et al., 2021). Cultural attributes have been studied in many species of cetaceans, principally in bottlenose dolphins (*Tursiops* sp.), Atlantic spotted dolphins (*Stenella frontalis*), killer whales (*Orcinus orca*), sperm whales (*Physeter macrocephalus*), and humpback whales (Whitehead et al., 2004; Krützen et al., 2005; Marino et al., 2007; Bender et al., 2009).

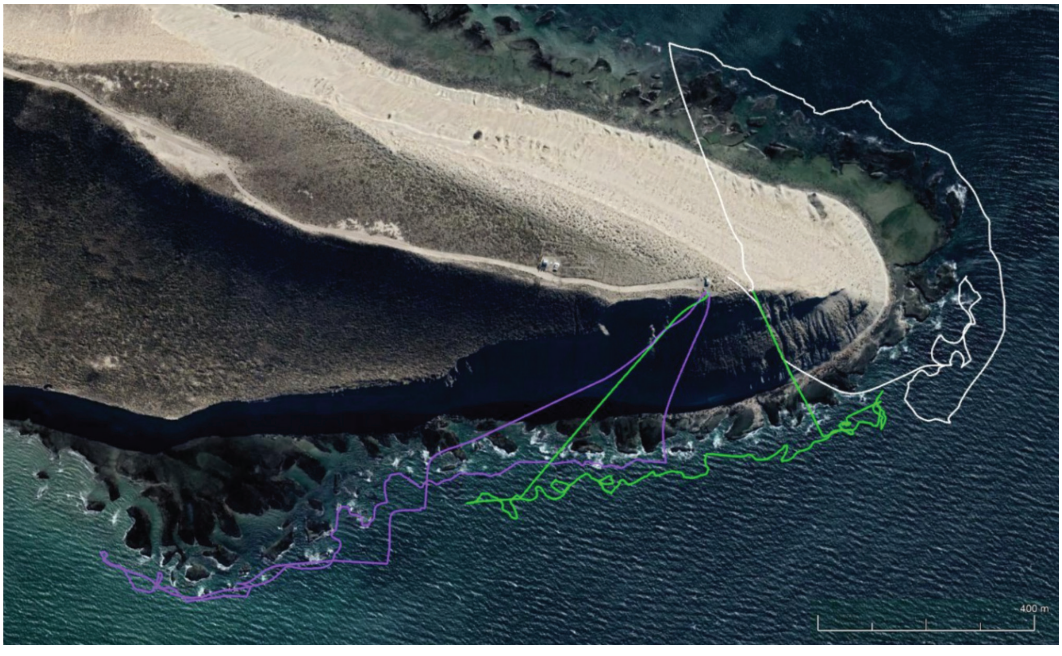

Figure 3. Example of three tracks of drone flights performed on 30 May and 1 June 2019 while the humpback whale was feeding. The pattern of natural barrier feeding was visible with the drone as it followed the whale while it was swimming towards the abrasion platform and the following swim in the opposite direction.

In the present study, at least three individuals performed the natural barrier feeding behavior: two identified individuals analyzed during the 2019 season and one previous record of an adult individual caught on camera in 2016. It is not possible to determine if cultural transmission was the mechanism involved in these observations, but it has been proposed already for the bloom of trap feeding near Vancouver Island, British Columbia (McMillan et al., 2019), and lobtail-feeding on Stellwagen Bank, near Boston, Massachusetts (Allen et al., 2013). There are no records of natural barrier feeding in Golfo San Jorge during the 2020 season because we were not able to sample due to the COVID-19 pandemic; nevertheless, in the coming years, effort will be made to document the behavior and identify individuals performing it.

These observations lead us to hypothesize that at least some humpback whales use the coastal waters off Patagonia for migration—for example, when they travel from their breeding area in Southern Brazil to their feeding location off South Georgia and the South Sandwich Islands (Zerbini et al., 2006). It is yet to be confirmed that these individuals belong to the BSA, but efforts are being made to biopsy sample humpback whales in the area.

The individual that remained the longest (roughly 10 d) performing this behavior in the area was a juvenile (classified by its length). It is possible that this young, sexually immature whale did not go to the population's usual breeding area in that particular season but to an alternative habitat where it could feed during winter and spring (Swingle et al., 1993).

This new record of humpback whales in the nearshore Southwestern Atlantic Ocean may call for management actions, mainly because there is no enforcement of the restrictions for recreational navigation in this area. In the Chubut province, it is forbidden to go whale watching without a formal permit (Chalcobsky et al., 2017). In the last 10 years, there has been an increase in the frequency of records of humpback and sei whales (*Balaenoptera borealis*) in the study area (Riera et al., 2019). To date, new entrepreneurs are interested in developing a new whale-watching area based on recurrent sightings; and if humpback whales are using this area as a feeding stop during their migration, it should be managed with caution.

Acknowledgments

This study was made under permits granted by the Ministerio de Turismo y Áreas Protegidas y la Dirección de Fauna y Flora Silvestre de la Provincia del Chubut (Disposición No. 59, SsCyAP/19; Disposición No. 70, DFyFS M.P./19). The authors thank Municipalidad de Rada Tilly and Panamerican Energy SA for logistical support. We especially thank Melina Beatriz Páez and Alberto Loizaga for reviewing the footage, curating the videos, and logistical support.

Literature Cited

Acevedo, J., Plana, J., Aguayo-Lobo, A., & Pastene, L. A. (2011). Surface feeding behavior of humpback whales in the Magellan Strait. *Revista de Biología Marina y Oceanografía*, *46*, 483-490. https://doi.org/10.4067/S0718-19572011000300018

Acevedo, J., Aguayo-Lobo, A., González, A., Haro, D., Olave, C., Quezada, F., Martínez, F., Garthe, S., & Cáceres, B. (2017). Occurrence of sei whales (*Balaenoptera borealis*) in the Magellan Strait from 2004-2015, Chile. *Aquatic Mammals*, *43*(1), 63-72. https://doi.org/10.1578/AM.43.1.2017.63

Allen, J., Weinrich, M., Hoppitt, W., & Rendell, L. (2013). Network-based diffusion analysis reveals cultural transmission of lobtail feeding in humpback whales. *Science*, *340*(6131), 485-488. https://doi.org/10.1126/science.1231976

Bender, C. E., Herzing, D. L., & Bjorklund, D. F. (2009). Evidence of teaching in Atlantic spotted dolphins (*Stenella frontalis*) by mother dolphins foraging in the presence of their calves. *Animal Cognition*, *12*(1), 43-53. https://doi.org/10.1007/s10071-008-0169-9

Bortolotto, G. A., Kolesnikovas, C. K. M., Freire, A. S., & Simões-Lopes, P. C. (2016a). Young humpback whale *Megaptera novaeangliae* feeding in Santa Catarina coastal waters, Southern Brazil, and a ship strike report. *Marine Biodiversity Records*, *9*(1), 1-6. https://doi.org/10.1186/s41200-016-0043-4

Bortolotto, G. A., Danilewicz, D., Andriolo, A., Secchi, E. R., & Zerbini, A. N. (2016b). Whale, whale, everywhere: Increasing abundance of western South Atlantic humpback whales (*Megaptera novaeangliae*) in their wintering grounds. *PLOS ONE*, *11*(10), e0164596. https://doi.org/10.1371/journal.pone.0164596

Brakes, P., Carroll, E. L., Dall, S. R., Keith, S. A., McGregor, P. K., Mesnick, S. L., Noad, M. J., Rendell, L., Robbins, M. M., & Rutz, C. (2021). A deepening understanding of animal culture suggests lessons for conservation. *Proceedings of the Royal Society B: Biological Sciences*, *288*(1949), 20202718. https://doi.org/10.1098/rspb.2020.2718

Chalcobsky, B. A., Crespo, E. A., & Coscarella, M. A. (2017). Whale-watching in Patagonia: What regulation scheme should be implemented when the socio-ecological system is changing? *Marine Policy*, *75*, 165-173. https://doi.org/10.1016/j.marpol.2016.11.010

Chenoweth, E. M., Straley, J. M., McPhee, M. V., Atkinson, S., & Reifenstuhl, S. (2017). Humpback whales feed on hatchery-released juvenile salmon. *Royal Society Open Science*, *4*(7), 170180. https://doi.org/10.1098/rsos.170180

Christiansen, F., Dujon, A. M., Sprogis, K. R., Arnould, J. P., & Bejder, L. (2016). 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

Clapham, P. J. (2000). The humpback whale. In J. Mann, R. C. Connor, P. L. Tyack, & H. Whitehead (Eds.), *Cetacean societies: Field studies of dolphins and whales* (pp. 173-196). The University of Chicago.

Cypriano-Souza, A. L., Fernandez, G. P., Lima-Rosa, C. A. V., Engel, M. H., & Bonatto, S. L. (2010). Microsatellite genetic characterization of the humpback whale (*Megaptera novaeangliae*) breeding ground off Brazil (Breeding Stock A). *Journal of Heredity*, *101*(2), 189-200. https://doi.org/10.1093/jhered/esp097

Dawbin, W. H. (1966). The seasonal migratory cycle of humpback whales. In K. S. Norris (Ed.), *Whales, dolphins, and porpoises* (pp. 145-170). University of California Press. https://doi.org/10.1525/9780520321373-011

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

Dellabianca, N. A., & Gribaudo, C. A. (2019). *Megaptera novaeangliae*. In Secretaría de Ambiente y Desarrollo Sustentable de la Nación y Sociedad Argentina para el Estudio de los Mamíferos (SAyDS–SAREM) (Ed.), *Categorización 2019 de los mamíferos de Argentina según su riesgo de extinción: Lista roja de los mamíferos de Argentina* [2019 categorization of Argentine mammals according to the risk of extinction: Red list of Argentine mammals]. SAyDS–SAREM. http://cma.sarem.org.ar

Eisenmann, P., Fry, B., Holyoake, C., Coughran, D., Nicol, S., & Bengtson Nash, S. (2016). Isotopic evidence of a wide spectrum of feeding strategies in Southern Hemisphere humpback whale baleen records. *PLOS ONE*, *11*(5), e0156698. https://doi.org/10.1371/journal.pone.0156698

Findlay, K. P., Seakamela, S. M., Meÿer, M. A., Kirkman, S. P., Barendse, J., Cade, D. E., Hurwitz, D., Kennedy, A. S., Kotze, P. G. H., McCue, S. A., Thornton, M., Vargas-Fonseca, O. A., & Wilke, C. G. (2017). Humpback whale "super-groups"—A novel low-latitude feeding behaviour of Southern Hemisphere humpback whales (*Megaptera novaeangliae*) in the Benguela Upwelling System. *PLOS ONE*, *12*(3), e0172002. https://doi.org/10.1371/journal.pone.0172002

Fiori, L., Martinez, E., Bader, M. K. F., Orams, M. B., & Bollard, B. (2020). Insights into the use of an unmanned aerial vehicle (UAV) to investigate the behavior of humpback whales (*Megaptera novaeangliae*) in Vava'u,

Kingdom of Tonga. *Marine Mammal Science*, *36*(1), 209-223. https://doi.org/10.1111/mms.12637

Garland, E. C., Goldizen, A. W., Rekdahl, M. L., Constantine, R., Garrigue, C., Hauser, N. D., Poole, M. M., Robbins, J., & Noad, M. J. (2011). Dynamic horizontal cultural transmission of humpback whale song at the ocean basin scale. *Current Biology*, *21*(8), 687-691. https://doi.org/10.1016/j.cub.2011.03.019

Hain, J. H. W., Carter, G. R., Kraus, S. D., Mayo, C. A., & Winn, H. E. (1982). Feeding behavior of the humpback whale, *Megaptera novaeangliae*, in the western North Atlantic. *Fishery Bulletin*, *80*(2), 259-268.

Hain, J. H. W., Ellis, S. L., Kenney, R. D., Clapham, P. J., Gray, B. K., Weinrich, M. T., & Babb, I. G. (1995). Apparent bottom feeding by humpback whales on Stellwagen Bank. *Marine Mammal Science*, *11*(4), 464-479. https://doi.org/10.1111/j.1748-7692.1995.tb00670.x

Helweg, D. A., Eriksen, N., Tougaard, J., & Miller, L. A. (2005). Cultural change in the songs of humpback whales (*Megaptera novaeangliae*) from Tonga. *Behaviour*, *142*(3), 305-328. https://doi.org/10.1163/1568539053778283

Herzing, D. L. (2005). Transmission mechanisms of social learning in dolphins: Underwater observations of free-ranging dolphins in the Bahamas. In F. Delfour & M. J. Dubois (Eds.), *Autour de l'ethologie et de la cognition animale* [Around ethology and animal cognition] (pp. 185-194). Presses Universitaires de Lyon.

International Whaling Commission (IWC). (1998). Annex G – Report of the Sub-Committee on the Comprehensive Assessment of Southern Hemisphere Humpback Whales. In IWC (Ed.), *Reports of the International Whaling Commission* (pp. 170-182). IWC.

Jurasz, C. M., & Jurasz, V. P. (1979). Feeding modes of the humpback whale, *Megaptera novaeangliae*, in southeast Alaska. *Scientific Reports of the Whales Research Institute*, *31*, 69-83.

Kosma, M. M., Werth, A. J., Szabo, A. R., & Straley, J. M. (2019). Pectoral herding: An innovative tactic for humpback whale foraging. *Royal Society Open Science*, *6*(10), 191104. https://doi.org/10.1098/rsos.191104

Krützen, M., Mann, J., Heithaus, M. R., Connor, R. C., Bejder, L., & Sherwin, W. B. (2005). Cultural transmission of tool use in bottlenose dolphins. *Proceedings of the National Academy of Sciences*, *102*(25), 8939-8943. https://doi.org/10.1073/pnas.0500232102

Marino, L., Connor, R. C., Fordyce, R. E., Herman, L. M., Hof, P. R., Lefebvre, L., Lusseau, D., McCowan, B., Nimchinsky, E. A., & Pack, A. A. (2007). Cetaceans have complex brains for complex cognition. *PLOS BIOLOGY*, *5*(5), e139. https://doi.org/10.1371/journal.pbio.0050139

McMillan, C. J., Towers, J. R., & Hildering, J. (2019). The innovation and diffusion of "trap-feeding," a novel humpback whale foraging strategy. *Marine Mammal Science*, *35*(3), 779-796. https://doi.org/10.1111/mms.12557

Riera, M. G., Páez, M. B., Lucchetti, D. D., Loizaga, A., & Coscarella, M. A. (2019). Nueva técnica de alimentación de yubartas (*Megaptera novaeangliae*) en el Área Natural Protegida Punta Marqués, Patagonia, Argentina [New feeding technique for humpback whales (*Megaptera novaeangliae*) in the Punta Marqués Protected Natural Area, Patagonia, Argentina]. *XXXII JAM*, Puerto Madryn.

Swingle, W. M., Barco, S. G., Pitchford, T. D., McLellan, W. A., & Pabst, D. A. (1993). Appearance of juvenile humpback whales feeding in the nearshore waters of Virginia. *Marine Mammal Science*, *9*(3), 309-315. https://doi.org/10.1111/j.1748-7692.1993.tb00458.x

Ward, E., Zerbini, A. N., Kinas, P. G., Engel, M. H., & Andriolo, A. (2011). Estimates of population growth rates of humpback whales (*Megaptera novaeangliae*) in the wintering grounds off the coast of Brazil (Breeding Stock A). *Journal of Cetacean Research and Management* (Special Issue 3), 145-149. https://doi.org/10.47536/jcrm.vi3.323

Weinrich, M. T., Schilling, M. R., & Belt, C. R. (1992). Evidence for acquisition of a novel feeding behaviour: Lobtail feeding in humpback whales, *Megaptera novaeangliae*. *Animal Behaviour*, *44*(6), 1059-1072. https://doi.org/10.1016/S0003-3472(05)80318-5

Whitehead, H., & Rendell, L. (2014). *The cultural lives of whales and dolphins*. The University of Chicago Press. https://doi.org/10.7208/chicago/9780226187426.001.0001

Whitehead, H., Rendell, L., Osborne, R. W., & Würsig, B. (2004). Culture and conservation of non-humans with reference to whales and dolphins: Review and new directions. *Biological Conservation*, *120*(3), 427-437. https://doi.org/10.1016/j.biocon.2004.03.017

Zar, J. (1996). *Introductory biostatistics*. Prentice Hall.

Zerbini, A. N., Ward, E. J., Kinas, P. G., Engel, M. H., & Andriolo, A. (2011). A Bayesian assessment of the conservation status of humpback whales (*Megaptera novaeangliae*) in the western South Atlantic Ocean. *Journal of Cetacean Research and Management* (Special Issue 3), 131-144. https://doi.org/10.47536/jcrm.vi3.320

Zerbini, A. N., Andriolo, A., Heide-Jørgensen, M. P., Pizzorno, J. L., Maia, Y. G., VanBlaricom, G. R., DeMaster, D. P., Simões-Lopes, P. C., Moreira, S., & Bethlem, C. (2006). Satellite-monitored movements of humpback whales *Megaptera novaeangliae* in the Southwest Atlantic Ocean. *Marine Ecology Progress Series*, *313*, 295-304. https://doi.org/10.3354/meps313295