Aquatic Mammals 2023, *49*(3), 274-281, DOI 10.1578/AM.49.3.2023.274

Short Note

Curly Tails: Rare Occurrence of Bent Flukes in Free-Ranging Cetaceans

Macarena Santos-Carvallo,[1,2] Frederick Toro,[3,4] María José Pérez-Alvarez,[2,5,6,7]
Maritza Sepúlveda,[1,2,8] and Jonathan González[9]

[1]*Centro de Investigación y Gestión de Recursos Naturales (CIGREN), Instituto de Biología, Facultad de Ciencias, Universidad de Valparaíso, Gran Bretaña 1111, Valparaíso, Chile*
E-mail: macarena.santos@uv.cl
[2]*Centro de Investigación Eutropia, Ahumada 832, Santiago, Chile*
[3]*Escuela de Medicina Veterinaria, Facultad de Recursos Naturales y Medicina Veterinaria, Universidad Santo Tomás, 1 Norte 3041, Viña del Mar, Chile*
[4]*ONG Panthalassa, Red de Estudios de Vertebrados Marinos en Chile, Santiago, Chile*
[5]*Escuela de Medicina Veterinaria, Facultad de Medicina y Ciencias de la Salud, Universidad Mayor, Camino La Pirámide 5750, Santiago, Chile*
[6]*Instituto de Ecología y Biodiversidad (IEB), Universidad de Chile, Las Encinas 3292, Santiago, Chile*
[7]*Instituto Milenio de Biodiversidad de Ecosistemas Antárticos y Subantárticos (BASE), Las Palmeras 3425, Santiago, Chile*
[8]*Núcleo Milenio INVASAL, Víctor Lamas 1290, Concepción, Chile*
[9]*Turismos Orca, Caleta Chañaral s/n, Chañaral de Aceituno, Atacama, Chile*

Dorsal fins, pectoral fins, and flukes are among the most important morphological structures of fully aquatic animals, including cetaceans (Fish, 1996). These structures are involved in the processes of thermoregulation, locomotion, stability, and maneuverability (Scholander & Schevill, 1955; Fish, 1996; Weber et al., 2014; Fish & Lauder, 2017), among others. Flukes particularly play an essential role as a propulsive organ contributing to gross body behavior, and they are of critical relevance in body hydrodynamics (Felts, 1966). In cetaceans, the flukes are composed of a thick skin layer, a subcutaneous blubber layer, a ligamentous layer, a series of arterio-venous plexuses, and a core of dense fibrous tissue (Felts, 1966; Sun et al., 2010). The ligamentous layer, in particular, is constituted by flexor and extensor tendons that are formed from epaxial and hypaxial muscles that reach the caudal portion (Spearman, 1972; Strickler, 1980). These ligaments are responsible for the movements of the fluke and maintain its flat horizontal shape (Strickler, 1980). The flukes are boneless, being firmer in the center and more flexible at the end with a slight curvature, allowing greater efficiency during movement (Fish, 1998).

To perform their functions adequately, the fins and flukes must be straight vertically (i.e., dorsal fin) or horizontally (i.e., fluke) as is regularly observed in cetaceans (Fish, 1998; Kastelein et al., 2016). However, some cases of abnormalities in these appendages have been reported, mainly in the dorsal fin, being partially or fully bent (Alves et al., 2018). In free-ranging cetaceans, both for odontocetes and mysticetes, it is estimated that the prevalence of this bending is nearly 1% (Alves et al., 2018). Exceptions are the orca (*Orcinus orca*) and the false killer whale (*Pseudorca crassidens*) for which the prevalence is close to 6 and 4%, respectively (Alves et al., 2018). These abnormalities may have a natural origin or be a consequence of anthropogenic interactions (Visser, 1998; Berghan & Visser, 2000; Baird & Gorgone, 2005; Luksenburg, 2014; Baird et al., 2015; Stack et al., 2019). Some of the natural causes of fin collapse can be congenital malformations, the height of the dorsal fin, infectious diseases, poor nutritional condition, and old age (in male orcas) (Alves et al., 2018). Physical injuries caused by boat strikes, interaction with fishing gear, and physiological stress have been described as possible anthropogenic causes of bent fins (Van Waerebeek et al., 2007; Luksenburg, 2014; Baird et al., 2015).

Reports of bent flukes are even less common. Castro et al. (2011) reported two individual humpback whales (*Megaptera novaeangliae*) (among 800 photo-identified individuals) with one of the flukes curved ventrally, describing them as deformities but without referring to the potential causes. There are also records on social media and web pages of both free-ranging (https://www.instagram.com/p/CN0u9oaBu1n/?utm_medium=share_sheet) and captive (https://www.instagram.com/p/CTAZ03iKavx/?utm_medium=copy_link) orcas with bent flukes. However, possible causes explaining these events are not discussed or even mentioned. Herein, we document a rare occurrence of bent flukes in orcas and humpback whales in the north-central waters of Chile. We also discuss potential causes of these rare abnormalities.

The Marine Reserve Isla Chañaral (29.09º S, 71.59º W) is located 6 km offshore from the north-central Chilean coast. A high diversity of marine fauna has been reported in the area, including several species of cetaceans such as bottlenose (*Tursiops truncatus*) and dusky dolphins (*Lagenorhynchus obscurus*); orcas; and blue (*Balaenoptera musculus*), fin (*B. physalus*), and humpback whales, among others (Capella et al., 1999; Pérez et al., 2006; Toro et al., 2016; Sepúlveda et al., 2018). Associated with this high diversity of species, whale-watching activities are currently being developed as an important economic activity in the Caleta Chañaral de Aceituno (Sepúlveda et al., 2018; Santos-Carvallo et al., 2021; Toro et al., 2021). Marine fauna records obtained by tourism operators have been increasing over time, mostly due to the fact that they have been training on species identification and behavioral responses and that they have been equipped with professional photographic equipment. During the whale-watching operations in the Marine Reserve, two records of bent flukes in two cetacean species were obtained. Observations were performed from a 9-m whale-watching boat with a 300-hp outboard motor. The animals were approximately 100 m from the boat. The species were identified by their diagnostic characteristics following Clapham (2009) and Ford (2009), and were recorded using a Canon 7D Mark II (Canon Inc., Tokyo, Japan) and autofocus 70-300 mm zoom lenses. Behavioral states of the animals were identified following Lusseau et al. (2009) for the orca and Di Clemente et al. (2018) for the humpback whale.

The first record was of a male orca on 21 December 2020 (Figure 1). The observed individual was part of a group composed of four orcas—two males, one probable female, and one juvenile. The orcas were exhibiting socializing behavior (Noren et al., 2009). At the beginning of the dives, one of the males raised its fluke, and it was observed that it had a slight ventral bend in a bilaterally symmetrical way (Figure 1a-c). The flukes were rigid, maintaining the same position continuously. The general condition of the animal was considered healthy, with no evidence of malnutrition (e.g., the dorsal spinous processes of the thoracic vertebrae were not observed) or lesions associated with pathogens or wounds caused by natural or anthropogenic causes. The movement of this individual was normal, maintaining the swimming velocity of the rest of the individuals in the group (Arbelo et al., 2013; Lauderdale et al., 2021).

The second record was of an adult humpback whale on 30 July 2021 (Figure 2). It was a solitary individual who was feeding and later resting (Brown et al., 1994). In this case, the ventral curvature of both flukes was considerable and bilaterally symmetrical (Figure 2a & b). As with the orca record, the flukes were rigid, constantly maintaining the same position. Parallel linear scars were observed at the tip of the right fluke, which were likely attributable to a bite from a predator such as an orca (Naessig & Lanyon, 2004; McCordic et al., 2014; Figure 2a). Additionally, scars likely attributable to interactions with fishing gear were recorded on the leading edge of the right fluke (Basran et al., 2019; Figure 2c). On the back and on the right side, the animal presented linear abrasive wounds parallel to the body, likely wounds generated by monofilament gears used in fishing activities (Figure 2d). Finally, further cranially linear (perpendicular to the body) and circular abrasive wounds were observed, which are associated with nets of multifilament fishing lines or larger fishing lines (Basran et al., 2019; Figure 2d). The animal was found in poor nutritional condition, with the spinous processes of the thoracic vertebrae clearly visible (Raverty et al., 2020).

The sources of these abnormalities (i.e., bent flukes in orcas and humpback whales) can be diverse and brought about by one or more causes. Regarding the possible causes of the occurrences of these abnormalities, Alves et al. (2018) suggested that the collapse of the dorsal fins could be associated with the individual's own condition (e.g., congenital malformations) and/or produced by external causes, whether natural (e.g., predator attack) or anthropogenic (e.g., interaction with fishing gear). The curvature of the flukes in the orca was less pronounced than in the humpback whale, and the animal did not show obvious signs of interactions that could explain this anomaly. The humpback whale, however, presented potential indications of interactions that could have caused or contributed to the bend of the flukes. Within these, it has been described that predator bites, depending on their intensity and/or frequency, may cause injury to the tendons, potentially generating the loss of their functionality and thus affecting the horizontal rigidity of the flukes (Cozzi et al., 2017). Fishing gear can cause additional weight on the flukes and increased

Figure 1. Male orca (*Orcinus orca*) with bent flukes: (a) posterior view of the flukes, (b) view from the right side of the fluke, and (c) the individual's dorsal fin. (*Photo credit:* Jonathan González, Turismos Orca)

Figure 2. Sighting of a humpback whale (*Megaptera novaeangliae*) with bent flukes: (a) posterior view shows a scar attributable to a predator bite (white circle) and (b) view from the right side of the fluke. (*Photo credit:* Jonathan González, Turismos Orca)

Figure 2 (cont.). Sighting of a humpback whale: (c) markings on the flukes attributable to an entanglement in fishing gear (white circle) and (d) a circular and linear abrasive wound (white circle) and parallel abrasive wounds (white box) on the back attributable to an entanglement. (*Photo credit:* Jonathan González, Turismos Orca) resistance, which can increase the energetic cost of locomotion (van der Hoop et al., 2017) and also affect the tendons and musculature of this appendage (Cozzi et al., 2017).

For the orca, the slight curvature in the flukes did not seem to affect the social and biological dynamics of the individual. It was observed in adequate nutritional condition with regular movements similar to the rest of the individuals in the group. This anomaly appears to be relatively common in free-ranging orcas since there are records of animals with similar characteristics in different parts of the world (e.g., United States [https://www.instagram.com/p/CN0u9oaBu1n/?utm_medium=share_sheet], Canada [https://grizzlybearwatching.com/tag/killer-whales/page/5], South Africa [https://www.hermanusonline.mobi/a-new-group-of-killer-whales-have-moved-to-south-africa-and-they-have-an-appetite-for-sharks]), and it could be a congenital malformation as described in dorsal fins (Alves et al., 2018). A different situation would be facing the humpback whale since the collapse of the flukes was more severe with a modification in the fluke span (i.e., linear distance between fluke tips), losing the proportional relationship with the body length (Bose et al., 1990). As described by Bose et al. (1990), this alteration in the flukes could cause less efficient movements and, consequently, an increase in energy costs by the animal (Fish, 1998). Smaller tail size in proportion to the body length of the animal has been described for some neonatal cetaceans, such as bottlenose dolphin (Noren et al., 2006) and Dall's porpoise (*Phocoenoides dalli*; Amano & Miyazaki, 1993), causing a lower swimming velocity compared to adult animals, forcing the calf to develop other strategies to match the adult's speed (e.g., free-riding behaviors; Lang, 1966). This suggests that the humpback whale was at a physical disadvantage compared to non-affected individuals of the same species, which would explain its decreased nutritional condition.

Both events were recorded during tourism operations, drawing the attention of tour operators and tourists. The participation of the community and citizens in gathering scientific information (known as citizen science) is becoming increasingly relevant, contributing to the gathering of scientific information and helping in recording new discoveries (Silvertown, 2009). Citizen science makes it possible to gain records in remote places, significantly increasing the observation and monitoring opportunities over time (Pacheco et al., 2019; Garcia-Cegarra et al., 2021). It is therefore important to encourage local communities to continue with the collection of these records, which could contribute to the observation and monitoring of these rare phenomena over time. Likewise, sharing and disseminating these records with neighboring communities can be useful for tracking the movements and habitat use of these affected individuals.

In summary, bent flukes have not been reported in free-ranging cetaceans in the scientific literature; therefore, there are no reports describing the causes of this abnormality. For the orca, the bend of the flukes was slight and appeared to not affect the individual. For the humpback whale, the bend was more obvious, and the flukes showed evidence of attacks from predators and interactions with fishing gear. Such interactions could cause or at least contribute to the bend of the flukes. Citizen science has become an important tool to record rare occurrences and contributes to gathering scientific information.

Acknowledgments

We thank Turismos Orca for allowing us to use their tourism platform and the tour operators of Caleta Chañaral de Aceituno. We also thank Kobe Martin for the English revision and the anonymous reviewer for valuable comments on the text. MJPA was partially funded by ANID-Millennium Science Initiative Program–ICN2021_002. MSM was partially supported by Núcleo Milenio INVASAL, which is funded by ANID-Programa Iniciativa Científica Milenio-NCN16_034.

Literature Cited

Alves, F., Towers, J. R., Baird, R. W., Bearzi, G., Bonizzoni, S., Ferreira, R., Halicka, Z., Alessandrini, A., Kopelman, A. H., Yzoard, C., Rasmussen, M. H., Bertulli, C. G., Jourdain, E., Gullan, A., Rocha, D., Hupman, K., Mrusczok, M-T., Samarra, F. I. P., Magalhães, S., Weir, C. R., . . . Dinis, A. (2018). The incidence of bent dorsal fins in free-ranging cetaceans. *Journal of Anatomy*, *232*(2), 263-269. https://doi.org/10.1111/joa.12729

Amano, M., & Miyazaki, N. (1993). External morphology of Dall's porpoise (*Phocoenoides dalli*): Growth and sexual dimorphism. *Canadian Journal of Zoology*, *71*, 1124-1130. https://doi.org/10.1139/z93-153

Arbelo, M., de Los Monteros, A. E., Herráez, P., Andrada, M., Sierra, E., Rodríguez, F., Jepson, P. D., & Fernández, A. (2013). Pathology and causes of death of stranded cetaceans in the Canary Islands (1999–2005). *Diseases of Aquatic Organisms*, *103*(2), 87-99. https://doi.org/10.3354/dao02558

Baird, R. W., & Gorgone, A. M. (2005). False killer whale dorsal fin disfigurement as a possible indicator of longline fishery interactions in Hawaiian waters. *Pacific Science*, *59*, 593-601. https://doi.org/10.1353/psc.2005.0042

Baird, R. W., Mahaffy, S. D., Gorgone, A. M., Cullins, T., McSweeney, D. J., Oleson, E. M., Bradford, A. L., Barlow, J., & Webster, D. L. (2015). False killer whales and fisheries interactions in Hawaiian waters: Evidence for sex bias and variation among populations and social groups. *Marine Mammal Science*, *31*(2), 579-590. https://doi.org/10.1111/mms.12177

Basran, C. J., Bertulli, C. G., Cecchetti, A., Rasmussen, M. H., Whittaker, M., & Robbins, J. (2019). First estimates of entanglement rate of humpback whales *Megaptera novaeangliae* observed in coastal Icelandic waters. *Endangered Species Research*, *38*, 67-77. https://doi.org/10.3354/esr00936

Berghan, J., & Visser, I. N. (2000). Vertebral column malformations in New Zealand delphinids with a review of cases worldwide. *Aquatic Mammals*, *26*(1), 17-25.

Bose, N., Lien, J., & Ahia, J. (1990). Measurements of the bodies and flukes of several cetacean species. *Proceedings of the Royal Society B: Biological Sciences*, *242*(1305), 163-173. https://doi.org/10.1098/rspb.1990.0120

Brown, M. R., Corkeron, P. J., Hale, P. T., Schultz, K. W., & Bryden, M. M. (1994). Behavioral responses of east Australian humpback whales *Megaptera novaeangliae* to biopsy sampling. *Marine Mammal Science*, *10*(4), 391-400. https://doi.org/10.1111/j.1748-7692.1994.tb00496.x

Capella, J., Vilina, Y., & Gibbons, J. (1999). Observación de cetáceos en isla Chañaral y nuevos registros para el área de la Reserva Nacional Pingüino de Humboldt, norte de Chile [Observation of cetaceans on Chañaral Island and new records for the area of the Humboldt Penguin National Reserve, northern Chile]. *Estudios Oceanológicos*, *18*, 57-64.

Castro, C., Kaufman, G., & Maldini, D. (2011). *A preliminary review of skin conditions and other body anomalies observed on humpback whales (*Megaptera novaeangliae*) from Ecuador* (SC/63/SH18). International Whaling Commission Scientific Committee.

Clapham, P. J. (2009). Humpback whale: *Megaptera novaeangliae*. In W. F. Perrin, B. Würsig, & J. G. M. Thewissen (Eds.), *Encyclopedia of marine mammals* (pp. 582-585). Academic Press. https://doi.org/10.1016/B978-0-12-373553-9.00135-8

Cozzi, B., Huggenberger, S., & Oelschläger, H. H. A. (2017). Brain, spinal cord, and cranial nerves. In B. Cozzi, S. Huggenberger, & H. H. A. Oelschläger (Eds.), *The anatomy of dolphins: Insights into body structure and function* (pp. 191-285). Academic Press. https://doi.org/10.1016/B978-0-12-407229-9.00006-3

Di Clemente, J., Christiansen, F., Pirotta, E., Steckler, D., Wahlberg, M., & Pearson, H. C. (2018). Effects of whale watching on the activity budgets of humpback whales, *Megaptera novaeangliae* (Borowski, 1781), on a feeding ground. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *28*(4), 810-820. https://doi.org/10.1002/aqc.2909

Felts, W. J. L. (1966). Some functional and structural characteristics of cetacean flippers and flukes. In K. S. Norris (Ed.), *Whales, dolphins and porpoises* (pp. 255-276). University of California Press. https://doi.org/10.1525/9780520321373-016

Fish, F. E. (1996). Transitions from drag-based to lift-based propulsion in mammalian swimming. *American Zoologist*, *36*, 628-641. https://doi.org/10.1093/icb/36.6.628

Fish, F. E. (1998). Biomechanical perspective on the origin of cetacean flukes. In J. G. M. Thewissen (Ed.), *The emergence of whales* (pp. 303-324). Springer. https://doi.org/10.1007/978-1-4899-0159-0_10

Fish, F. E., & Lauder, G. V. (2017). Control surfaces of aquatic vertebrates: Active and passive design and function. *Journal of Experimental Biology*, *220*, 4351-4363. https://doi.org/10.1242/jeb.149617

Ford, J. K. B. (2009). Killer whale: *Orcinus orca*. In W. F. Perrin, B. Würsig, & J. G. M. Thewissen (Eds.), *Encyclopedia of marine mammals* (pp. 650-657). Academic Press. https://doi.org/10.1016/B978-0-12-373553-9.00150-4

Garcia-Cegarra, A. M., Toro, F., & Gonzalez-Borasca, V. (2021). Citizen science as a tool to assess cetacean diversity in the Atacama Desert coast. *Ocean & Coastal Management*, *213*, 105858. https://doi.org/10.1016/j.ocecoaman.2021.105858

Kastelein, R. A., Triesscheijn, R. J. V., & Jennings, N. (2016). Reversible bending of the dorsal fins of harbor porpoises (*Phocoena phocoena*) and a striped dolphin (*Stenella coeruleoalba*) in captivity. *Aquatic Mammals*, *42*(2), 218-226. https://doi.org/10.1578/AM.42.2.2016.218

Lang, T. G. (1966). Hydrodynamic analysis of cetacean performance. In K. S. Norris (Ed.), *Whales, dolphins and porpoises* (pp. 410-432). University of California Press. https://doi.org/10.1525/9780520321373-021

Lauderdale, L. K., Mellen, J. D., Walsh, M. T., Granger, D. A., & Miller, L. J. (2021). Towards understanding the welfare of cetaceans in accredited zoos and aquariums. *PLOS ONE*, *16*(8), e0255506. https://doi.org/10.1371/journal.pone.0255506

Luksenburg, J. A. (2014). Prevalence of external injuries in small cetaceans in Aruban waters, southern Caribbean. *PLOS ONE*, *9*(2), e88988. https://doi.org/10.1371/journal.pone.0088988

Lusseau, D., Bain, D. E., Williams, R., & Smith, J. C. (2009). Vessel traffic disrupts the foraging behavior of southern resident killer whales *Orcinus orca*. *Endangered Species Research*, *6*, 211-221. https://doi.org/10.3354/esr00154

McCordic, J. A., Todd, S. K., & Stevick, P. T. (2014). Differential rates of killer whale attacks on humpback whales in the North Atlantic as determined by scarification. *Journal of the Marine Biological Association of the United Kingdom*, *94*(6), 1311-1315. https://doi.org/10.1017/S0025315413001008

Naessig, P. J., & Lanyon, J. M. (2004). Levels and probable origin of predatory scarring on humpback whales (*Megaptera novaeangliae*) in east Australian waters. *Wildlife Research*, *31*(2), 163-170. https://doi.org/10.1071/WR03086

Noren, D. P., Johnson, A. H., Rehder, D., & Larson, A. (2009). Close approaches by vessels elicit surface active behaviors by southern resident killer whales.

Endangered Species Research, *8*, 179-192. https://doi.org/10.3354/esr00205

Noren, S. R., Biedenbach, G., & Edwards, E. F. (2006). Ontogeny of swim performance and mechanics in bottlenose dolphins (*Tursiops truncatus*). *Journal of Experimental Biology*, *209*(23), 4724-4731. https://doi.org/10.1242/jeb.02566

Pacheco, A. S., Silva, S., Alcorta, B., Gubbins, S., Guidino, C., Sanchez-Salazar, F., Petit, A., Llapapasca, M. A., Balducci, N., Larrañaga, E., Zapata, M. A., Grados, E., Valdivia, C., Pinasco, G., Garcia-Cegarra, A. M., Cáceres, D., Biffi, D., Silva, L., Auger, A., Borda, D., . . . Jaramillo-Calle, V. (2019). Cetacean diversity revealed from whale-watching observations in northern Peru. *Aquatic Mammals*, *45*(1), 116-123. https://doi.org/10.1578/AM.45.1.2019.116

Pérez, M., Thomas, F., Uribe, F., Sepúlveda, M., Flores, M., & Moraga, R. (2006). Fin whales (*Balaenoptera physalus*) feeding on *Euphausia mucronata* in nearshore waters off north-central Chile. *Aquatic Mammals*, *32*(1), 109-113. https://doi.org/10.1578/AM.32.1.2006.109

Raverty, S., St. Leger, J., Noren, D. P., Huntington, K. B., Rotstein, D. S., Gulland, F. M. D., Ford, J. K. B., Hanson, M. B., Lambourn, D. M., Huggins, J., Delaney, M. A., Spaven, L., Rowles, T., Barre, L., Cottrell, P., Ellis, G., Goldstein, T., Terio, K., Duffield, D., Rice, J., & Gaydos, J. K. (2020). Pathology findings and correlation with body condition index in stranded killer whales (*Orcinus orca*) in the northeastern Pacific and Hawaii from 2004 to 2013. *PLOS ONE*, *15*(12), e0242505. https://doi.org/10.1371/journal.pone.0242505

Santos-Carvallo, M., Barilari, F., Pérez-Alvarez, M. J., Gutiérrez, L., Pavez, G., Araya, H., Anguita, C., Cerda, C., & Sepúlveda, M. (2021). Impacts of whale-watching on the short-term behavior of fin whales (*Balaenoptera physalus*) in a Marine Protected Area in the southeastern Pacific. *Frontiers in Marine Science*, *8*, 623954. https://doi.org/10.3389/fmars.2021.623954

Scholander, P. F., & Schevill, W. E. (1955). Counter-current vascular heat exchange in the fins of whales. *Journal of Applied Physiology*, *8*(3), 279-282. https://doi.org/10.1152/jappl.1955.8.3.279

Sepúlveda, M., Pérez-Alvarez, M. J., Santos-Carvallo, M., Pavez, G., Olavarría, C., Moraga, R., & Zerbini, A. N. (2018). From whaling to whale watching: Identifying fin whale critical foraging habitats off the Chilean coast. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *28*(4), 821-829. https://doi.org/10.1002/aqc.2899

Silvertown, J. (2009). A new dawn for citizen science. *Trends in Ecology & Evolution*, *24*(9), 467-471. https://doi.org/10.1016/j.tree.2009.03.017

Spearman, R. I. (1972). The epidermal stratum corneum of the whale. *Journal of Anatomy*, *113*(Pt. 3), 373-381.

Stack, S. H., Currie, J. J., McCordic, J. A., & Olson, G. L. (2019). Incidence of odontocetes with dorsal fin collapse in Maui Nui, Hawaii. *Aquatic Mammals*, *45*(3), 257-265. https://doi.org/10.1578/AM.45.3.2019.257

Strickler, T. L. (1980). The axial musculature of *Pontoporia blainvillei*, with comments on the organization of this system and its effect on fluke-stroke dynamics in the Cetacea. *American Journal of Anatomy*, *157*(1), 49-59. https://doi.org/10.1002/aja.1001570106

Sun, Q., Morikawa, H., Kobayashi, S., Ueda, K., Miyahara, H., & Nakashima, M. (2010). Structure and bending properties of central part of tail fin of dolphin. *Journal of Biomechanical Science and Engineering*, *5*(4), 388-398. https://doi.org/10.1299/jbse.5.388

Toro, F., Vilina, Y. A., Capella, J. J., & Gibbons, J. (2016). Novel coastal feeding area for eastern South Pacific fin whales (*Balaenoptera physalus*) in mid-latitude Humboldt Current waters off Chile. *Aquatic Mammals*, *42*(1), 47-55. https://doi.org/10.1578/AM.42.1.2016.47

Toro, F., Alarcón, J., Toro-Barros, B., Mallea, G., Capella, J., Umaran-Young, C., Abarca, P., Lakestani, N., Peña, C., Alvarado-Rybak, M., Cruz, F., Vilina, Y., & Gibbons, J. (2021). Spatial and temporal effects of whale watching on a tourism-naive resident population of bottlenose dolphins (*Tursiops truncatus*) in the Humboldt Penguin National Reserve, Chile. *Frontiers in Marine Science*, *8*, 624974. https://doi.org/10.3389/fmars.2021.624974

van der Hoop, J., Corkeron, P. J., & Moore, M. (2017). Entanglement is a costly life-history stage in large whales. *Ecology and Evolution*, *7*(1), 92-106. https://doi.org/10.1002/ece3.2615

Van Waerebeek, K., Baker, A. N., Félix, F., Gedamke, J., Iñiguez, M., Sanino, G. P., Secchi, E., Sutaria, D., van Helden, A., & Wang, Y. (2007). Vessel collisions with small cetaceans worldwide and with large whales in the Southern Hemisphere, an initial assessment. *Latin American Journal of Aquatic Mammals*, *6*(1), 43-69. https://doi.org/10.5597/lajam00109

Visser, I. N. (1998). Prolific body scars and collapsing dorsal fins on killer whales (*Orcinus orca*) in New Zealand waters. *Aquatic Mammals*, *24*(2), 71-82.

Weber, P. W., Howle, L. E., Murray, M. M., Reidenberg, J. S., & Fish, F. E. (2014). Hydrodynamic performance of the flippers of large-bodied cetaceans in relation to locomotor ecology. *Marine Mammal Science*, *30*(2), 413-432. https://doi.org/10.1111/mms.12040