Latin American Journal of Aquatic Mammals
www.lajamjournal.org
Online ISSN: 2236-1057

Report of two fin whale (*Balaenoptera physalus*) strandings associated with ship strikes in central-south coast of Chile

Frederick Toro[†,‡,§,¶], Josefina Gutiérrez[§,#,¶¶], Analía Henríquez[&], Jorge Leichtle[§,&], Nelson Follador[‡,▽], Paulette Abarca[‡,§,¶,††], Camila Calderón[‡‡], Claudia Peña[§], Paula Aravena[§,§§], Alexis Henríquez[¶], David Rodríguez[¶], Constanza Sánchez[¶] and Betsy Pincheira[§]

[†]Centro de Investigación para la Sustentabilidad y Doctorado en Medicina de la Conservación, Facultad de Ciencias de la Vida, Universidad Andres Bello, Republica 252, Santiago, Chile
[‡]Panthalassa, Red de Estudios de Vertebrados Marinos de Chile, Toesca 2002 P6, Santiago, Chile
[§]Asociación de Médicos Veterinarios de Fauna Silvestre, AMEVEFAS, Comuna de Santiago, Región Metropolitana, Chile
[¶]Universidad Santo Tomás, Escuela de Medicina Veterinaria, Sede Viña del Mar, Avenida Limonares #190, Viña del Mar, Chile
[#]Instituto de Patología Animal, Facultad de Ciencias Veterinarias, Universidad Austral de Chile, Campus Isla Teja S/N UACh, Valdivia, Chile
[$]epi3lab, Faculty of Medicine, Pontificia Universidad Católica de Chile, Marcoleta 391, Santiago, Chile
[&]Facultad de Medicina Veterinaria, Universidad San Sebastián, Lientur 1457 Concepción, Chile
[▽]Laboratorio de Ecología y Evolución, Departamento de Ciencias Básicas, Facultad de Ciencias, Universidad del Bío-Bío, Casilla 447, Chillán, Chile
[††]Programa de Magíster en Ciencias mención Biodiversidad y Conservación, Universidad de Valparaíso, Gran Bretaña 1111, Playa Ancha,Valparaíso, Chile
[‡‡]Centro de Investigación Oceanográfica COPAS Sur-Austral y Programa de Magíster en Ciencias mención Oceanografía, Departamento de Oceanografía, Universidad de Concepción, Barrio Universitario s/n, Concepción, Chile
[§§]Laboratorio de Vida Silvestre de la Facultad de Ciencias Veterinarias de la Universidad de Concepción, Avda. Vicente Méndez 595, Chillán, Chile
[¶¶]Escuela de Graduados, Facultad de Ciencias Veterinarias, Universidad Austral de Chile, Valdivia, Chile
* Corresponding author: frederick.toro.c@gmail.com

Article Info

Manuscript type	Note
Article history	
Received	25 May 2019
Received in revised form	20 September 2019
Accepted	07 November 2019
Available online	31 July 2020
Responsible Editor: Diana Szteren	
Citation: Toro, F., Gutiérrez, J., M., Henríquez, A., Leichtle, J., Follador, N., Abarca, P., Calderón, C., Peña, C., Aravena, P., Henríquez, A., Rodríguez, D., Sánchez, C. and Pincheira, B. (2020) Report of two fin whale (*Balaenoptera physalus*) strandings associated with ship strikes in central-south coast of Chile. *Latin American Journal of Aquatic Mammals* 15(1): 8-14. https://doi.org/10.5597/lajam00255	

Evidence of ship strikes in large whales has increased in the last decades, alarming the scientific community, authorities and public in general. These interactions may produce serious injuries, such as bone fractures, lacerations, hemorrhages and, in certain cases, instant death (Moore *et al.*, 2004; Campbell-Malone *et al.*, 2008). This constitutes a constant threat for a great number of endangered species (Clapham *et al.*, 1999; Waring *et al.*, 2011), which has been reported worldwide. For instance, in the US North Atlantic, a total of 28 whales killed by ship strikes have been recorded between 2007 and 2011 (Henry *et al.,* 2013), constituting the main cause of death for northern right whales (*Eubalaena glacialis*) (Van der Hoop *et al.,* 2012). Globally, the number of at least 9 species of large cetaceans killed by ship strikes has increased up to 119 individuals (Laist *et al.*, 2001; Jensen and Silber, 2003; Van Waerebeek *et al.*, 2007). The International Whaling Commission (IWC) database recorded around 1200 ship strikes events from 2007 until May 2016 (IWC, 2019).

Collisions between vessels and cetaceans have also been documented in Chile in the past decades as well[1,2] (Canto *et al.*, 1991; Hucke-Gaete *et al.*, 2005; Van Waerebeek *et al.*, 2007), with an estimated prevalence from 4% of all stranded cetaceans nationally[3] to 33% of stranding causes in central Chile between the years 2003-2004 (Sanino and Yañez,

[1]Brownell, R., Carlson, C., Vernazzani, B. and Cabrera, E. (2008) Skin lesions on blue whales off southern Chile. *Paper SC/60/SH25* presented to the IWC Scientific Committee, June 2008, Santiago, Chile. 8 pp. [Paper available from the Office of this Journal].

[2]Hucke-Gaete, R., Viddi, F. and Bello, M. (2005) Blue whales off southern Chile: Overview of research achievements and current conservation challenges (*Document SC/57/SH5*). Presented to the 57th International Whaling Commission Scientific Committee Meeting, Ulsan, Korea. 13 pp.

[3]Galletti-Vernazzani, B. and Cabrera, E. (2007) Varamiento de cetáceos en Chile 1970-2005 y su relación con impactos antropogénicos. Pages 32-37 *in* Félix, F. (Ed.) *Memorias del Taller de Trabajo sobre Impacto de las Actividades Antropogénicas en Mamíferos Marinos en el Pacífico Sudeste*. Bogotá, Colombia-Guayaquil, Ecuador: CPPS/PNUMA.

2005). Nevertheless, it is often not possible to determine the cause of death in stranded whales due to high decomposition levels (Henry *et al.*, 2013).

Baleen whale sightings have increased along the Chilean coasts during the last decade. Particularly, a large fraction of fin whales (*Balaenoptera physalus*) have been reported to concentrate in the north-central region (Garcia-Cegarra and Pacheco, 2019), either near the Humboldt Penguin National Reserve islands, described as a foraging area for this species (Toro *et al.*, 2016; Sepúlveda *et al.*, 2018), or in Mejillones Bay (Pacheco *et al.*, 2015; Garcia-Cegarra and Pacheco, 2019). Likewise, sightings have been reported throughout the Pacific coast, possibly migrating individuals to or from Antarctica. Fin whale is a species particularly vulnerable to ship strikes, with the highest number of recorded interactions and mortality around the world (Van Waerebeek *et al.*, 2007; Jimenez *et al.,* 2019; Pirotta *et al.,* 2019). Examination of stranded cetaceans provides a valuable source of information for anatomical, biological and ecological data of lesser known species, allows evaluation of human activity impact on marine environments and effects of pathogens on animal and human health (Groch *et al.,* 2018). Thus, our goal through this note is to describe the findings of two necropsies performed on *B. physalus* stranded on the central-south coast of Chile, relate them to the presence of vessels in the stranding areas and discuss maritime traffic implications in the mortality and conservation of this species.

Two fin whales stranded dead during a one-year period (2018-2019) in the Chilean coasts (Fig. 1A) and necropsies were performed. One was located in San Vicente de Talcahuano (36°43' S - 73°07' W; Fig. 1C), which services forestry, fishing and agricultural industries for three vast areas in southern Chile, and is located less than 50 kilometers from two high density ports, presenting a joint density of 1480 vessel calls in 2018[4]. The second specimen was located in Santo Domingo, 4 kilometers south of San Antonio (33°36' S - 71°37' W; Fig. 1B), the main port in Chile, and 90 kilometers south of Valparaiso, both ports with a high large vessel density, reaching up to 2151 joint ship calls in 2018[4]. A heat map was developed to visualize the density of vessel calls for both areas close to the strandings, created through QGIS 3.8.2 (QGIS Development Team, 2019).

In each stranding location, an initial assessment of the individual and surrounding area was conducted to record possible presence of other stranded specimens. Additionally, photographs were taken in each site from land and air, the latter with an unmanned aerial vehicle (Figs 2A and B). Morphometric parameters were taken with a measuring tape (meters), based on Norris' (1961) methodology, where

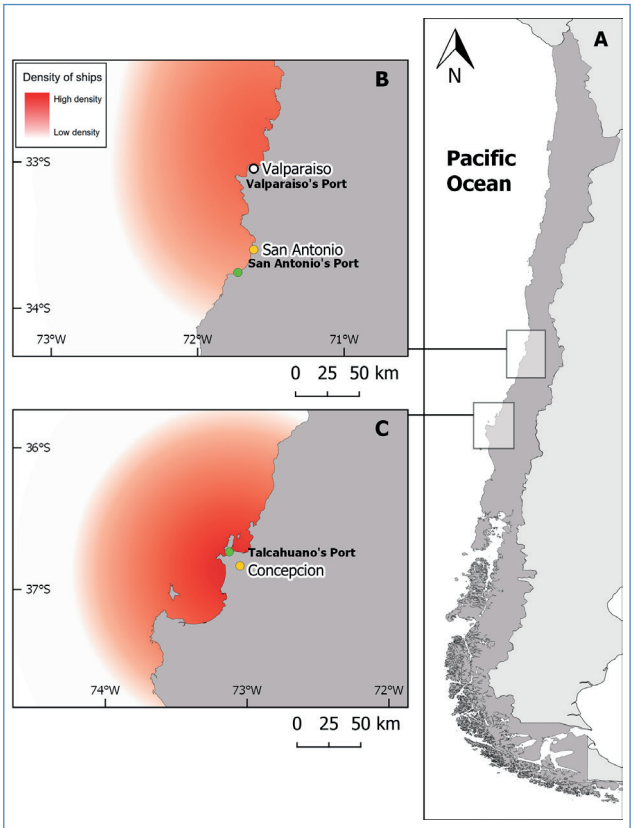

Figure 1. (A) Map of Chile, showing fin whale (*Balaenoptera physalus)* strandings 2018-2019; (B) area of Santo Domingo near San Antonio port (yellow circle) in central Chile and near Valparaiso port (white circle) (C) San Vicente de Talcahuano Bay in Talcahuano, near Concepción (yellow circle). Stranding sites are shown in green circles. Heatmaps in B and C (red shade) illustrate densities of ship traffic in Valparaíso-San Antonio and Talcahuano-San Vicente-Coronel ports respectively, Chile.

each measurement was conducted parallel to the body axis. Necropsies were performed following Pugliares' *et al.* (2007) protocol for large cetaceans, that includes external and internal examination. In both procedures samples of lungs, liver, stomach, muscle, intestine, baleen plates, subcutaneous fat tissue and skin were collected. All samples were preserved in ethanol (70% and 95%) and 10% buffered formalin[5] (Geraci *et al.*, 1979; Pugliares *et al.*, 2007), except baleen plates, which were kept without chemical preserver, for trophic ecology studies. These samples were collected for future genetic, histopathological, microbiology, parasitology and toxicology studies.

The Talcahuano individual was found floating dead by a fishing boat on 23 May 2018 and towed to the closest beach. The necropsy was performed two days later, at San Vicente beach (36°44'1.84" S - 73°07'32.56" W). The carcass was in

[4]Armada de Chile, DIRECTEMAR (2019) Maritime Statistical Bulletin of the Chilean Navy. Available online at [https://www.directemar.cl/directemar/estadisticas-maritimas/boletin-estadistico-maritimo/historico/boletin-estadistico-maritimo-edicion-2018] Consulted on 16 March 2019.

[5]Winchell, J.M. (1990) Field manual for Phocoenid necropsies. *NOAA Tech. Memo. NMFS*. NOAA-TM-NMFS-SWFC-14. 55 pp.

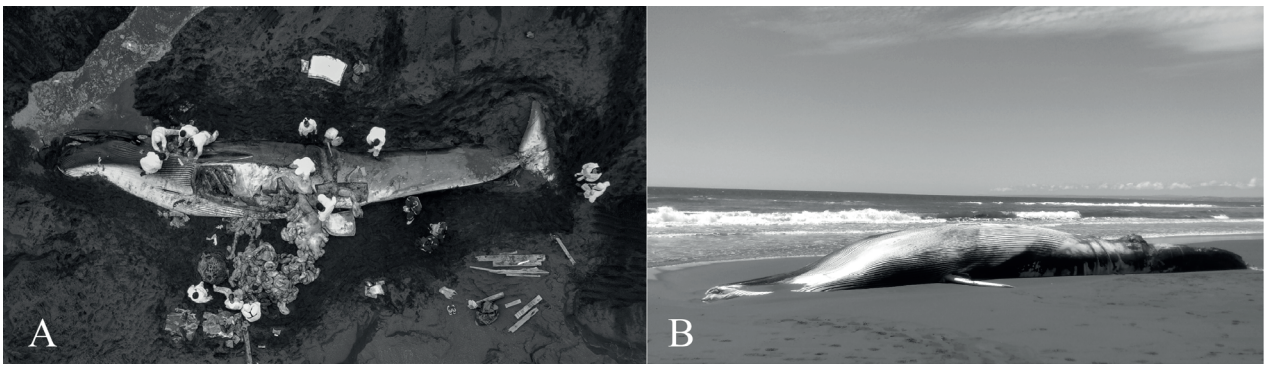

Figure 2. (A) Aerial view of fin whale necropsy (*Balaenoptera physalus*), San Vicente, Talcahuano; (B) Lateral view of fin whale stranded at Santo Domingo, San Antonio.

Table 1. Morphometrics of two immature individuals of fin whale (*Balaenoptera physalus)* stranded in Talcahuano and Santo Domingo ports in central and southern Chile, 2018 and 2019, respectively. All measurements in meters (m).

Biological information	Talcahuano	Santo Domingo
Sex	Male	Female
Total length	15.26	15.83
Width rostrum	2.89	-
Eye to blowhole border	1.19	-
Pectoral fin, axillary girth	0.91	0.98
Pectoral fin, anterior length	1.39	1.68
Pectoral fin, maximum width	0.53	0.33
Tip of upper jaw to anterior insert of dorsal fin	11.08	-
Dorsal fin width	0.75	-
Dorsal fin height	0.44	-
Fluke width (tip to tip)	3.46	-
Fluke notch to anterior insertion dorsal fin	3.94	-
Fluke notch to posterior insertion dorsal fin	3.51	-
Fluke notch to center anus	4.26	-
Fluke notch to genital slit	4.58	-
Fluke notch to center of umbilicus	5.43	-
Genital slit length	0.96	-

right lateral decubitus, although internal marks suggested a left lateral position for the first 24 hours *post mortem* (Fig. 2A). The specimen was a 15.26 m long immature male (Table 1), body condition 4/5, with 5 centimeters of fat thickness in the thoracic dorsal area and decomposition state 3, presented partial loss of superficial layers of the epidermis in some areas of the body and moderate meteorism (swelling) of the carcass (Pugliares *et al.*, 2007). A dorsal-cranial laceration on the left pectoral flipper including skin, subcutaneous and muscle of 1.5 x 1.5 m and 30 cm deep with loss of soft tissue was observed. Additionally, there was a 2 m long laceration in the ventral wall of the right lumbar area of the individual (30 cm lateral to the midline). The lesion presented rounded borders, skin and muscle tears, perforating into the abdominal cavity, with hemorrhage within the cavity and intestines.

The Santo Domingo specimen was found stranded at a sandy beach, with no rocky coast nearby, in the northern limit of El Yali National Reserve (33°43'45.17" S - 71°40'51.46" W; Fig. 1B) on 06 January 2019, and a partial necropsy was performed two days later. The individual was in dorsal recumbency, with the right side covered by sand, hindering morphometric measurements. To external examination it was an immature female and measured 15.83 m in total length (Table 1). Body condition was not visible due to advanced state of decomposition (state 4), most superficial layers of the epidermis were lost to the carcass observation. In the right abdominal region, multiple external parallel lines of lacerations with associated hematomas were visible (Fig. 3A).

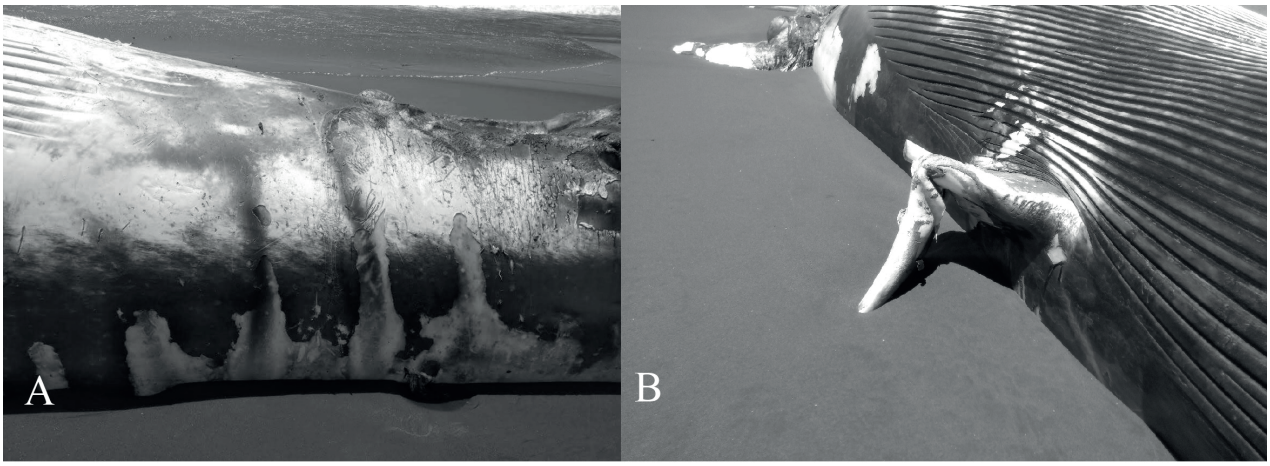

Figure 3. Lesions in fin whale (*Balaenoptera physalus*) stranded in Santo Domingo: (A) Injuries produced by large vessel propellers are observed in right abdominal region area; (B) Radius-ulna dislocation in the left pectoral fin.

These lesions are characteristic of interaction with large vessel propellers. Moreover, there were multiple hematomas in skin and muscles of the pelvic region, as well as lacerations in the caudal peduncle. There was also a blunt trauma injury in the left pectoral flipper, with possible dislocation of radius and ulna (Fig. 3B).

According to gross findings in both necropsies, causes of death were probably due to perforating trauma in the abdominal wall for the Talcahuano specimen, and a laceration in the abdominal region and left pectoral fin for the Santo Domingo individual. Abundant tissue in advanced state of decomposition was observed, limiting proper identification of other possible macro and/or microscopic lesions. Findings on skin (abdominal wall laceration), together with subcutaneous and intra-abdominal hematomas, suggest acute trauma, probably caused by the collision with a substantial structure, attributable to a large vessel, in both cases. Tissue reaction was considerable (*e.g.* abdominal wall tear, hematomas and internal adherences). Hemorrhagic enteritis observed in the Talcahuano specimen was possibly due to engagement of the small intestine, which caused a peri acute inflammatory reaction in the intestinal wall.

This report comprised the examination of two dead stranded fin whales in San Vicente de Talcahuano Bay and Santo Domingo Bay, Chile. Gross findings suggest collision with large ships as the probable cause of death. This is inferred from the locations of the strandings and the type of injuries found in both carcasses. Comparing the anatomical areas where lesions were found, differences were observed with those described in the Gulf of Maine (USA), where humpback whales (*Megaptera novaeangliae*) present more lesions in the dorsal right region of the body (Hill *et al.*, 2017). However, these same authors indicate that the higher prevalence of injuries in the dorsal region is due to higher probability of photographing that area, which suggests absence of registry of lesions in other parts of the body.

Considering the obtained morphometric measurements, we propose that both carcasses would correspond to immature weaned individuals (between 3 and 5 years of age), based on data described by Aguilar and Lockyer (1987) for the North Atlantic, and Mackintosh and Wheleer (1929) and Lockyer (1972) for Southern hemisphere populations. These findings are highly relevant for high concentration areas of immature specimens, such as the Humboldt Penguin National Reserve (Toro *et al.*, 2016; Sepúlveda *et al.*, 2018), since young animals are prone to higher mortality and injuries caused by ship strikes, as they spend more time on the surface, are less experienced and only learn to avoid ships at older ages (Panigada *et al.*, 2006). Therefore, a possible segregation by age could exist, with the immature being distributed near the central coast of Chile where higher risk of collisions exist (Sepúlveda *et al.*, 2018) and adults migrating to foraging grounds near Antarctica (Clarke, 1962; Clarke *et al.*, 1978).

Fin whales present the majority of reported cases of ship strikes within the order Cetacea (Laist *et al.*, 2001; Panigada *et al.*, 2006; Van Waerebeek *et al.*, 2007; Redfern *et al.*, 2013). However, reasons for this are unknown. Some possible causes could be attributed to their surface foraging behavior, as fin, together with blue whales (*Balaenoptera musculus*), present short diving periods during feeding and long recovery periods on the surface, with high energy costs (Goldbogen *et al.*, 2006), which would make them more susceptible to ships encounters. Additionally, there is the impact of environmental sounds produced by vessels that can induce behavioral changes in large whales (Blair *et al.,* 2016). This response can cause an increase in energy expenditure, given that the animals move away, stop feeding and reproducing in places with high ship noise (Castellote *et al.*, 2012).

For the Chilean coasts, there are no systematic records of fin whales with injuries or found dead by ship interactions in stranding reports, mainly because necropsies are rarely performed. The IWC has developed a global open database of large whales stricken by vessels, and encourages intercontinental collaboration, which contributes to a better

understanding of the problem worldwide, considering associated factors, mortality estimation, identification of high-risk areas and enhancement of mitigation measures (Cates *et al.,* 2017). Due to the magnitude of the ventral injury found in the Talcahuano specimen, it is probable that the collision between the whale and the vessel occurred near the stranding site. Sepúlveda *et al.* (2018) described fin whale individual movements along Chilean coasts through satellite transmitters. They defined three relevant areas for this species near the continental shelf: Copiapo to Coquimbo, near Valparaíso (33°35' S) and near Concepción (36°30' S). Both southern areas present high maritime traffic (Fig. 1B and C), and therefore the increase in encounter probability. This high risk is also present in other areas, for example in Mejillones Bay, where spatial overlap between cargo ships and whales exist and photographic records of trauma and contusions have been published (Garcia-Cegarra and Pacheco, 2019).

Among dead stranded fin whales found in the Chilean coast during the last five years, at least four presented injuries associated with interaction with vessels (Sernapesca, 2019). Additionally, in 2016 a live fin whale with lacerations in the dorsal region, similar to those produced by large vessel propellers, was observed (Toro, pers. obs.). All the aforementioned dictates the necessity to permanently record injuries and traumas caused by ship strikes on large whales, especially in areas of high maritime traffic and abundance of cetaceans. Moreover, it is crucial to count with a professional multidisciplinary team to perform necropsies on all marine mammals found dead along the Chilean coastline, therefore identifying possible causes of death, and to propose preventive measures at a national level. This is relevant for the conservation of this and other whale species, since there are mega port initiatives in high concentration areas, with ship strikes constituting one of many potential risks linked to the presence of ships and ports along the country.

Acknowledgments

We give thanks to Servicio Nacional de Pesca (Sernapesca) Biobío and San Antonio, especially to Carlos Navarro and Astrid Guerra. Armada de Chile, Pesquera Blumar, Siderúrgica Huachipato, Asociación de Médicos Veterinarios de Fauna Silvestre (AMEVEFAS), Panthalassa NGO, Universidad Andrés Bello, Universidad San Sebastián sede Concepción, Universidad de Concepción sede Chillán and Concepción. Finally, we thank Pablo Espinoza for photograph for Fig. 1A, and Alexis Henríquez for photograph for Fig. 1B.

References

Aguilar, A. and Lockyer, C. (1987) Growth, physical maturity, and mortality of fin whales (*Balaenoptera physalus*) inhabiting the temperate waters of the northeast Atlantic. *Canadian Journal of Zoology* 65: 253-264. https://doi.org/10.1139/z87-040

Blair, H., Merchant, N. and Friedlaender, A. (2016) Evidence for ship noise impacts on humpback whale foraging behaviour. *Biology Letter* 12(8): 20160005. https://doi.org/10.1098/rsbl.2016.0005

Campbell-Malone, R., Barco, S., Daoust, P., Knowlton, A., McLellan, W., Rotstein, D. and Moore, M. (2008) Gross and histological evidence of sharp and blunt trauma in North Atlantic right whales (*Eubalaena glacialis*) killed by vessels. *Journal Zoo and Wildlife Medicine* 39(1): 37–55. https://doi.org/10.1638/2006-0057.1

Canto, J., Ruiz, P. and Cárdenas, J. (1991) Necropsy of southern right whale *Eubalaena australis* and considerations for management of the species. *Boletín Museo Nacional de Historia Natural Chile* 42: 105-111.

Castellote, M., Clark, C. and Lammers, M. (2012) Acoustic and behavioural changes by fin whales (*Balaenoptera physalus*) in response to shipping and airgun noise. *Biological Conservation* 147(1): 115–122. https://doi.org/10.1016/j.biocon.2011.12.021

Cates, K., DeMaster, D., Brownell Jr, R., Silber, G., Gende, S., Leaper, R., Ritter, F. and Panigada, S. (2017) Strategic Plan to Mitigate the Impacts of Ship Strikes on Cetacean Populations: 2017-2020. *Paper IWC/66/CC20* presented to the meeting of the Conservation Committee of the International Whaling Commission, March 2017. Available online at [https://iwc.int/private/downloads/dr1UJzeCuNpAWs9Xf9caBw/IWC_Strategic_Plan_on_Ship_Strikes_Working_Group_FINAL.pdf]

Clarke, R. (1962) Whale observation and whale marking off the coast of Chile in 1958 and from Ecuador towards and beyond the Galapagos Islands in 1959. *Norsk Hvalfangst-Tidende* 7: 265-287.

Clarke, R., Aguayo, A. and Basulto, S. (1978) Whale observation and whale marking off the coast of Chile in 1964. *The Scientific Reports of the Whale Research Institute* 30:117-177.

Clapham, P., Young, S. and Brownell, R. (1999) Baleen whales: conservation issues and the status of the most endangered populations. *Mammal Review* 29(1): 37–62. https://doi.org/10.1046/j.1365-2907.1999.00035.x

García-Cegarra, A. and Pacheco, A. (2019) Collision risk areas between fin and humpback whales with large cargo vessels in Mejillones Bay (23° S), northern Chile. *Marine Policy* 103:182-186. https://doi.org/10.1016/j.marpol.2018.12.022

Geraci, J.R., Hicks, B.D. and St Aubin, D.J. (1979) Dolphin pox: a skin disease of cetaceans. *Canadian Journal of Comparative Medicine* 43: 399-404.

Goldbogen, J., Calambokidis, J., Shadwick, R., Oleson, E., McDonald, M. and Hildebrand, J. (2006) Kinematics of foraging dives and lunge-feeding in fin whales. *Journal of Experimental Biology* 209(7): 1231–1244. https://doi.org/10.1242/jeb.02135

Groch, K., Díaz-Delgado, J., Marcondes, M., Colosio, A., Santos-Neto, E., Carvalho, V., Silva Boos, G., Oliveira de Meirelles, A., da Cunha Ramos, H., Plácido Guimarães, J., Gomes Borges, J., Vergara-Parente, J., St Leger, J., Fernández, A. and Catão-Dias, J. (2018) Pathology and causes of death in stranded humpback whales (*Megaptera novaeangliae*) from Brazil. *PLoS ONE* 13(5): e0194872. https://doi.org/10.1371/journal.pone.0194872

Henry, A., Cole, T., Hall, L., Ledwell, W., Morin, D. and Reid, A. (2013) Mortality determinations for baleen whale stocks along the Gulf of Mexico, United States East Coast, and Atlantic Canadian Provinces, 2007–2011. *US Department of Commerce, Northeast Fisheries Science Center Reference Document 13-18*. 15 pp. Available at https://repository.library.noaa.gov/view/noaa/4541/noaa_4541_DS1.pdf

Hill, A., Karniski, C., Robbins, J., Pitchford, T., Todd, S. and Asmutis-Silvia, R. (2017) Vessel collision injuries on live humpback whales, *Megaptera novaeangliae*, in the southern Gulf of Maine. *Marine Mammal Science* 33(2): 558-73. https://doi.org/10.1111/mms.12386

IWC (2019) *2019 Ship Strike Summary Data*. Available online at https://iwc.int/ship-strikes

Jensen, A. and Silber, G. (2003) Large whale ship strike database. U.S. Department of Commerce, *NOAA Technical Memorandum NMFS-F/OPR*, 37 pp. [Available from NMFS, East-West Highway, USA <https://www.greateratlantic.fisheries.noaa.gov/shipstrike/news/shipstrike03.pdf>]

Jiménez López, M.E., Palacios, D.M., Jaramillo Legorreta, A., Urbán R., J. and Mate, B.R. (2019) Fin whale movements in the Gulf of California, Mexico, from satellite telemetry. *PLoS ONE* 14(1): e0209324. https://doi.org/10.1371/journal.pone.0209324

Laist, D., Knowlton, A., Mead, J., Collet, A. and Podesta, M. (2001) Collisions between ships and whales. *Marine Mammal Science* 17(1): 35-75. https://doi.org/10.1111/j.1748-7692.2001.tb00980.x

Lockyer, C. (1972). The age at sexual maturity of the Southern fin whale (*Balaenoptera physalus*) using annual layer counts in the ear plug. *ICES Journal of Marine Science* 34(2): 276–294. https://doi.org/10.1093/icesjms/34.2.276

Mackintosh, N.A. and Wheeler, J.F.G. (1929) The Fin Whale, *Balaenoptera physalus*. *Marine Fisheries Review* 46(4): 257-540.

Moore, M., Knowlton, A., Kraus, S., McLellan, W. and Bonde, R. (2004) Morphometry, gross morphology and available histopathology in North Atlantic right whale (*Eubalena glacialis*) mortalities (1970–2002). *Journal of Cetacean Research and Management* 6(3): 199–214.

Norris, K.S. (1961) Standardized methods for measuring the recording data on the smaller cetaceans. *Journal of Mammalogy* 42:471-476. https://doi.org/10.2307/1377364

Pacheco, A., Villegas, V., Riascos, J. and Van Waerebeek, K. (2015) Presence of fin whales (*Balaenoptera physalus*) in Mejillones Bay, a major seaport area in northern Chile. *Revista de Biología Marina y Oceanografía* 50(2): 383-389. https://doi.org/10.4067/S0718-19572015000300017

Panigada, S., Pesante, G., Zanardelli, M., Capoulade, F., Gannier, A. and Weinrich, M. (2006) Mediterranean fin whales at risk from fatal ship strikes. *Marine Pollution Bulletin* 52: 1287-1298. https://doi.org/10.1016/j.marpolbul.2006.03.014

Pirotta, V., Grech, A., Jonsen, I., Laurance, W. and Harcourt, R. (2019) Consequences of global shipping traffic for marine giants. *Frontiers in Ecology and the Environment* 17(1): 39-47. https://doi.org/10.1002/fee.1987

Pugliares, K., Herzig, S., Bogomolni, A., Harry, C., Touhey, K. and Moore, M. (2007) Marine mammal necropsy: An introductory guide for stranding responders and field biologists. *Tech Doc 2007-06*. Woods Hole Oceanographic Institution, Woods Hole, MA. https://doi.org/10.1575/1912/1823

QGIS Development Team (2019) *QGIS Geographic Information System*. Open Source Geospatial Foundation Project. Available online at http://qgis.osgeo.org Consulted on 18 September 2019.

Redfern, J., McKenna, M., Moore, T., Calambokidis, J., Deangelis, M., Becker, E., Barlow, J., Forney, K., Fiedler, P. and Chivers, S. (2013) Assessing the risk of ships striking large whales in marine spatial planning. *Conservation Biology* 27(2): 292-302. https://doi.org/10.1111/cobi.12029

Sanino, G.P. and Yáñez, J. (2005) Registro de varamientos de grandes cetáceos en la costa de Chile. Período 2003- 2004. *Boletín Museo Nacional de Historia Natural* (Santiago, Chile) 54: 107-114.

Sepúlveda, M., Pérez-Álvarez, M.J., Santos-Carvallo, M., Pavez, G., Olavarría, C., Moraga, R. and Zerbini, A. (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

Servicio Nacional de Pesca (Sernapesca) (2019) *Registro de varamientos* [Stranding data]. Retrieved from www.sernapesca.cl

Toro, F., Vilina, Y., Capella, J. and Gibbons, J. (2016) Novel coastal feeding area for Eastern South Pacific fin whales (*Balaenoptera physalus*) in midlatitude Humboldt Current waters off Chile. *Aquatic Mammals* 42: 47–55. https://doi.org/10.1578/AM.42.1.2016.47

Van der Hoop, J., Vanderlaan, A. and Taggart, C. (2012) Absolute probability estimates of lethal vessel strikes to North Atlantic right whales in Roseway Basin, Scotian Shelf. *Ecological Applications* 22: 2021–2033. https://doi.org/10.1890/11-1841.1

Van Waerebeek, K., Baker, A., Felix, B., Gedmanke, J., Iñiguez, A., Sanino, G., Secchi, E., Sutaria, D., Van Helden, A. and 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): 43–49. https://doi.org/10.5597/lajam00109

Waring, G., Josephson, E., Maze-Foley, K. and Rosel, P. (2011) U.S. Atlantic and Gulf of Mexico marine mammal stock assessments 2011. *NOAA Technical Memorandum NMFS-NE* 221. Available online at [http://www.nefsc.noaa.gov/nefsc/publications/]