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What Do We Know About Cetaceans in the Mexican Waters of the Gulf of Mexico? A Review

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Abstract

The Gulf of Mexico (GOM) is a semi-closed basin that supports high marine biodiversity, and it is also an important economic area where the Exclusive Economic Zones (EEZs) of the United States, Mexico and Cuba converge. Twenty-one species of cetaceans are commonly sighted in the GOM, and although the population traits of most species are well known in the U.S. EEZ, the development of regional management plans is complicated because of the apparent lack of ecological data in the Mexican EEZ, which comprises about 50% of the entire GOM. The state of knowledge of cetaceans in Mexican waters was reviewed to identify current research trends and gaps. The results clearly show that the Mexican research effort is focused on a few coastal populations of a single species, the bottlenose dolphin (*Tursiops truncatus*), while the offshore cetacean populations are ignored; therefore, there are insufficient data to assess diversity, distribution, and abundance. Moreover, due to the high mobility of cetaceans and the transboundary nature of their ranges, the scientific community is currently not prepared to detect population trends in cetacean populations of the GOM. To accomplish this, two priorities were identified: (1) to expand and refocus the Mexican research capabilities, and (2) to implement binational monitoring programs.

Key Words: Mexican Exclusive Economic Zone, sighting records, peer-reviewed papers, research trends

Introduction

The Gulf of Mexico (GOM) is a semi-enclosed marine ecosystem connected to the Atlantic Ocean by the Florida Straits and to the Caribbean Sea by the Yucatan Channel. It is bounded to the north and northwest by the United States, to the south and southwest by Mexico, and to the east by Cuba, converging their Economic Exclusive Zones (EEZs) (Figure 1). Overall, it is an ecosystem of moderate productivity, ranging from eutrophic conditions in the coastal zones, strongly influenced by freshwater input from rivers, to oligotrophic conditions in deeper oceanic waters at its center (Heileman & Rabalais, 2009).

The GOM hosts significant marine biodiversity, with more than 15,400 recorded species; of these, 10% are endemic (Felder & Camp, 2009). Cetacean diversity is relatively high, with 21 common species in the U.S. EEZ (Jefferson & Schiro, 1997; Hildebrand et al., 2015; Würsig, 2017), which represents ~21% of global cetacean species diversity (Burgin et al., 2018). The Bryde's whale (*Balaenoptera edeni*) is the only mysticete (i.e., baleen whale), and it is distributed exclusively in the northwestern GOM (Soldevilla et al., 2017). The remaining 20 species are odontocetes (i.e., toothed cetaceans), with the most diverse being the Family Delphinidae with 14 species. Sightings and strandings of five baleen whales, as well as the Sowerby's beaked whale (*Mesoplodon bidens*), have been reported occasionally (Waring et al., 2016; Würsig, 2017).

The ecology of cetaceans in the GOM was poorly studied before the 1980s, but the establishment of the Southeastern United States Marine Mammal Stranding Network in 1977 marked the beginning of systematic research (Schmidly & Würsig, 2009). Large-scale surveys started in the 1980s; and since the late 1990s, the National

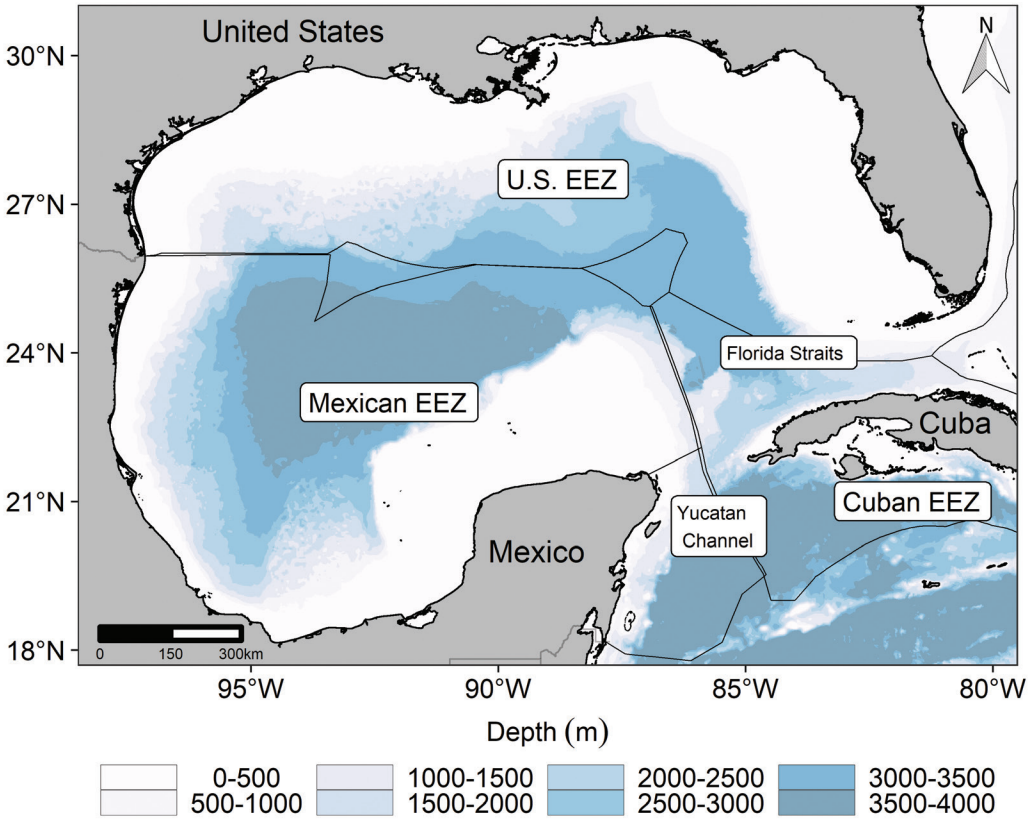

Figure 1. Gulf of Mexico (GOM) showing the Economic Exclusive Zones (EEZs) of the U.S., Mexico, and Cuba

Marine Fisheries Services and the U.S. Fish and Wildlife Service published annual U.S. Atlantic and Gulf of Mexico marine mammal stock assessments (National Oceanic and Atmospheric Administration [NOAA], 2020). In contrast, knowledge seems to be very limited inside the Mexican EEZ, which comprises about 50% of the total area of the GOM. Ortega-Ortiz (2002) presented the most extensive compilation of sightings, confirming the presence of ten commonly sighted species (Table 1). However, until the beginning of the 21st century, the information on basic ecology, including cetacean distribution and abundance, was practically non-existent (Ortega-Ortiz et al., 2004).

Besides its biological diversity, the GOM is an important economic area where fishing, tourism, and the hydrocarbon industry generate billions of dollars annually (Karnauskas et al., 2013). These activities place the GOM ecosystem under increasing anthropogenic pressure, but the development of regional management plans for cetaceans has been complicated by the apparent lack of ecological data inside the Mexican EEZ. In this article, there were two main objectives: (1) to update the database of sighting records within the Mexican waters of the GOM with information that has not been previously reported; and (2) to review the state of knowledge of cetaceans within the Mexican EEZ in order to evaluate research trends and identify knowledge gaps.

Methods

Sighting records up to 2018 were compiled from specialized literature. To avoid using misidentified records, the criteria of Jefferson & Schiro (1997) and Ortega-Ortiz (2002) were followed, and only those sightings for which there was proven evidence of correct identification based on diagnostic characteristics were included. Verified records were mapped (when the geographic coordinates were available), using the package 'ggplot2' (Wickham, 2010) for *R* software (R Core Team, 2018).

The state of knowledge was evaluated based on the number of papers, which is a good indicator of the research investment, assuming that if a work

Table 1. Sighting records of cetaceans in Mexican waters of the Gulf of Mexico (GOM), 1952 to 2018; scientific and common names were taken from Jefferson et al. (2015). [a]Occasional visitor; [b]non-listed by Ortega-Ortiz (2002).

Family	Species	Common name	Sightings in Mexican waters
Balaenopteridae	*Balaenoptera physalus*[a]	Fin whale	1
	Megaptera novaeangliae[a]	Humpback whale	1
Physeteridae	*Physeter macrocephalus*	Sperm whale	28
Kogiidae	*Kogia sima*	Dwarf sperm whale	1[b]
Delphinidae	*Orcinus orca*	Killer whale	2
	Pseudorca crassidens	False killer whale	5
	Feresa attenuata	Pygmy killer whale	1[b]
	Globicephala macrorhynchus	Short-finned pilot whale	50
	Steno bredanensis	Rough-toothed dolphin	39
	Grampus griseus	Risso's dolphin	3[b]
	Lagenodelphis hosei	Fraser's dolphin	1
	Stenella attenuata	Pantropical spotted dolphin	75
	Stenella clymene	Clymene dolphin	1[b]
	Stenella longirostris	Spinner dolphin	9
	Stenella frontalis	Atlantic spotted dolphin	155
	Tursiops truncatus	Bottlenose dolphin	3,569
Total			3,941

is published it is because the scientific quality standards were reached (Wilson et al., 2016). An exhaustive bibliographic review of peer-reviewed scientific papers was conducted using the databases of Elsevier, JSTOR, Web of Science, Wiley, and Redalyc. The production trend (number of papers over time) was evaluated, but because trends can vary in time, the freely available software *SegReg* (https://www.waterlog.info) was used to determine if there was a break-point in the time series—that is, to detect if the trend changed abruptly. Subsequently, the nonparametric Mann-Kendall (MK) test was used to assess whether the production trend was statistically different from zero and, if so, to determine its increasing or decreasing slope (Libiseller & Grimvall, 2002).

Study topics were divided into ten classes: (1) feeding and foraging, (2) anatomy and morphology, (3) evolution and phylogeny, (4) strandings, (5) socio-sexual behavior, (6) management and conservation, (7) population ecology, (8) genetics and biochemistry, (9) sampling techniques, and (10) animal health. To evaluate if there were changes both in the research lines and in the species studied between periods (see below), the method of *m* proportions (Fleiss, 1981) was used, which allows the carrying out of a hypothesis test on the equality of proportions of independent samples.

Results

Sighting Records

The oldest sighting record in Mexican waters dates back to 1952; and from then until 2018, a total of 3,941 records of 16 species were found (Table 1; Supplemental Appendix A: "Sighting Records of Cetaceans in Mexican Waters of the Gulf of Mexico") (Supplemental Appendices A & B are available in the "Supplemental Material" section on the *Aquatic Mammals* website: https://www.aquaticmammalsjournal.org/index.php?option=com_content&view=article&id=10&Itemid=147.) The sources of information were theses (64% of the total records), conference proceedings and abstracts (15%), scientific papers (15%), and technical reports (6%) (Supplemental Appendix A). Except for the records of the bottlenose dolphin (*Tursiops truncatus*), almost all sightings were recorded opportunistically, although some were collected in 14 surveys carried out by Mexican researchers in the 1980s (A. Aguayo-Lobo, unpub. data), six in the late 1990s (Ortega-Ortiz, 2002), three in the mid-2000s (Galindo et al., 2009; Vázquez-Castán et al., 2009), and four in the late 2010s (O. Sosa-Nishizaki, unpub. data). However, only six surveys were specifically designed for cetacean data collection (Galindo et al., 2009; O. Sosa-Nishizaki,

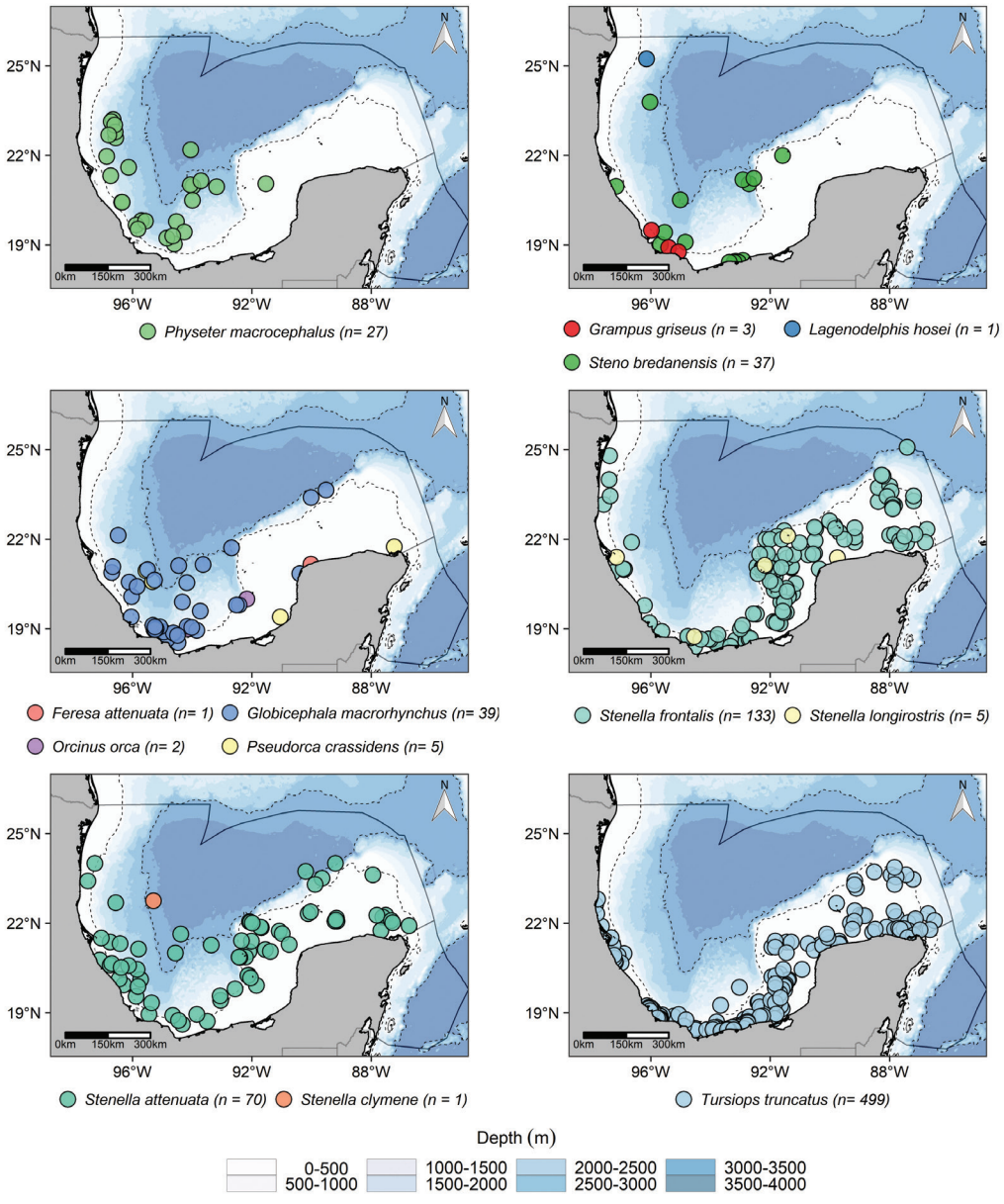

Figure 2. Cetacean sightings in the Mexican EEZ (solid line) of the GOM; dashed lines represented the 200 and 3,000 m isobaths.

unpub. data), while the remaining 21 were opportunistic surveys conducted during oceanographic cruises. Only 805 sightings of 13 species were georeferenced (Figure 2), and more than 95% of them were recorded on the continental shelf (< 200 m depth) and the inner slope (200 to 1,000 m depth).

Ninety-one percent of the records were of bottlenose dolphins (Table 1). Excluding these records, the most commonly sighted species in the Mexican EEZ were the Atlantic spotted dolphin (*Stenella frontalis*; 42% of the remaining 372 sightings), pantropical spotted dolphin (*S. attenuata*; 20%), short-finned pilot whale (*Globicephala macrorhynchus*; 13%), rough-toothed dolphin (*Steno bredanensis*; 10%), and sperm whale (*Physeter macrocephalus*; 8%). Sightings of killer whales (*Orcinus orca*), false

killer whales (*Pseudorca crassidens*), and spinner dolphins (*Stenella longirostris*) were scarce (< 10 each), while only one record was found for the Fraser's dolphin (*Lagenodelphis hosei*). There were also some sightings of fin whales (*Balaenoptera physalus*) and humpback whales (*Megaptera novaeangliae*).

Records of four species not previously reported by Ortega-Ortiz (2002) were found: (1) the dwarf sperm whale (*Kogia sima*), (2) pygmy killer whale (*Feresa attenuata*), (3) Clymene dolphin (*Stenella clymene*), and (4) Risso's dolphin (*Grampus griseus*). The only reported sighting of the dwarf sperm whale (not georeferenced and without group size data) occurred in the south of the GOM (off the Yucatan platform) in the period 2002-2003 (Antochiw-Alonzo & Manzano-Kantún, 2004). A group of 13 pygmy killer whales was sighted on the Yucatan platform in 2013 (Díaz-Gamboa, 2015), and a group of ~30 Clymene dolphins were sighted in the deep waters of the western GOM in 2008 (Vázquez-Castán et al., 2009) (Figure 2). There was one sighting of Risso's dolphins in 2015 (group size of ~40 individuals) and two in 2016 (group size of 4 and 3 individuals, respectively), all of them in the southwestern continental shelf-break (Castro-Proal, 2018) (Figure 2).

Scientific Production

Up until 2017, 281 scientific papers were found (see Supplemental Appendix B: "List of Peer-Reviewed Scientific Papers on Cetaceans of the Gulf of Mexico"). Two hundred and fifty-two papers were written by U.S. institutions (both government and academic) of which four extended to Mexican waters; the remaining 29 were carried out by Mexican institutions in Mexican waters. The oldest paper dates back to 1910, but no publications were found for the 1920s and 1930s; therefore, the trend analysis covered the period 1940 to 2017. The optimal break-point was found to be 1982 (Figure 3), so the study of the cetaceans of the GOM was divided into two periods: 1940 to 1982 ($n = 41$ papers) and 1983 to 2017 ($n = 240$ papers).

The MK test revealed positive and significant trends in both periods for U.S. scientific production, although production increased notably faster during the second period than in the first (Table 2). Regarding Mexican production, during the first period, only one paper was produced, while 28 papers were produced in the second period. There was no statistical evidence that the trend was different from zero between 1983 and 2017 (Table 2), suggesting that there has been no major development in research in the last 35 years.

Overall, both the topics and species of study have changed over time (Figure 4). Between the first and second period (41 and 240 papers, respectively), there was a significant reduction in the proportion of papers on strandings (39.0 to 5.0%; $\chi^2 = 15.22$, $p < 0.01$), while the proportion of animal health studies increased significantly (9.8 to 26.9%; $\chi^2 = 4.97$, $p = 0.03$), as well as the proportion of papers on bottlenose dolphins (24.4 to 61.1%; $\chi^2 = 5.78$, $p = 0.02$). Considering exclusively Mexican production during the period 1983 to 2017, the main topics were stranding reports and population ecology (both with 29.6% of the production), and more than half of the papers focused on the bottlenose dolphin (Figure 5).

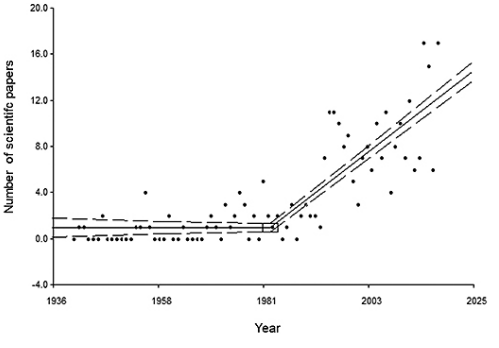

Figure 3. Scientific production on cetaceans of the GOM from 1940 to 2017. Solid rectangle represents the 90% confidence interval (CI) of the break-point (1982). Dashed lines represent the 90% CI of the two regressions: the first when X (year) is smaller or equal than the break-point and the second when X is greater than the break-point.

Table 2. Number of peer-reviewed papers (n) produced by country, Mann-Kendall test results (Z and p values), and the magnitude of the slope (b; papers per year) for the periods 1940 to 1982 and 1983 to 2017

	Period	n	Z	p	b
United States	1940-1982	40	2.34	0.02	0.04
	1983-2017	211	4.03	< 0.01	0.28
Mexico	1940-1982	1	--	--	--
	1983-2017	28	1.91	0.06	--

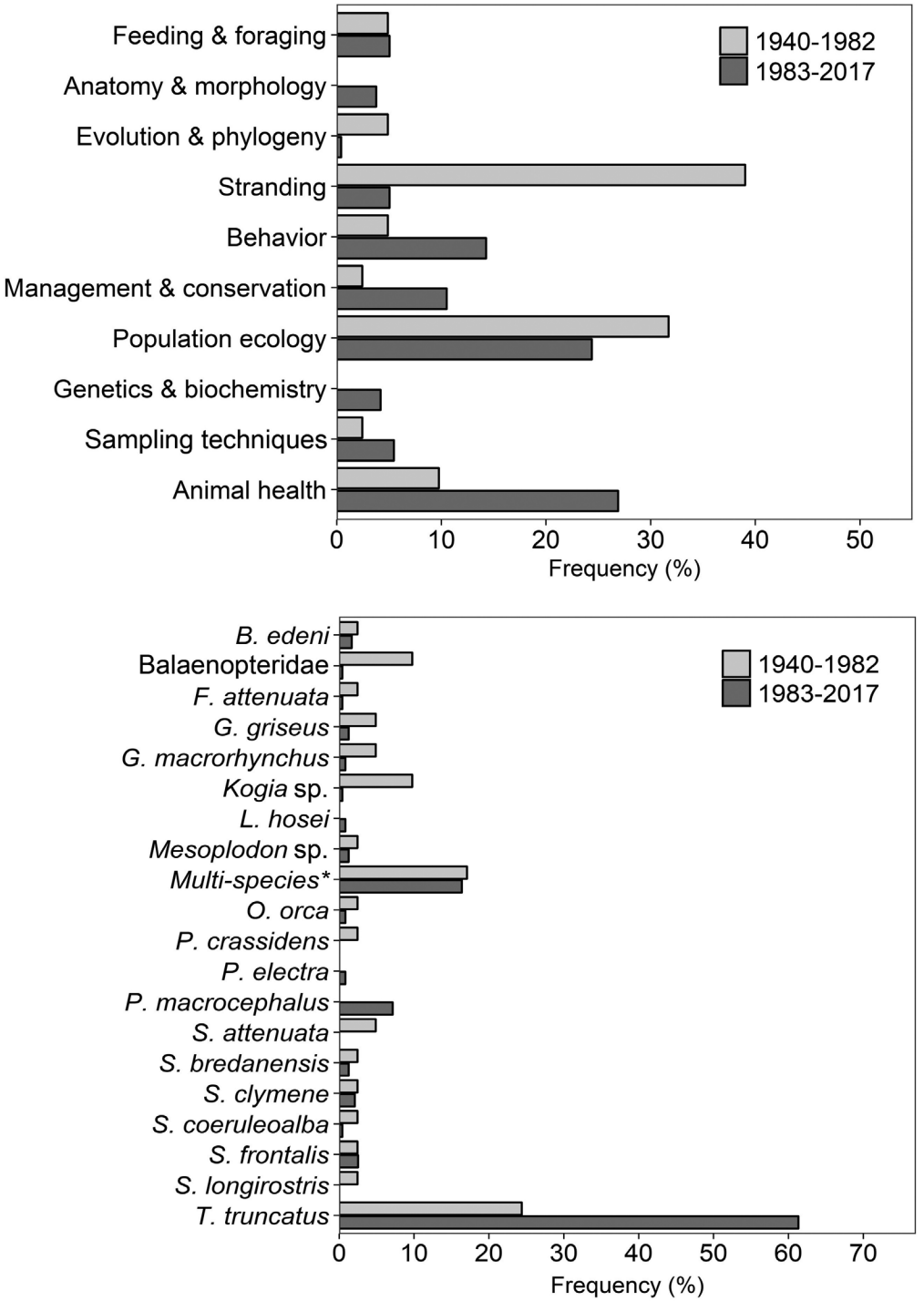

Figure 4. Comparison between periods of the proportion of scientific papers produced by topic (*top*) and by species (*bottom*). *Studies that include two or more species.

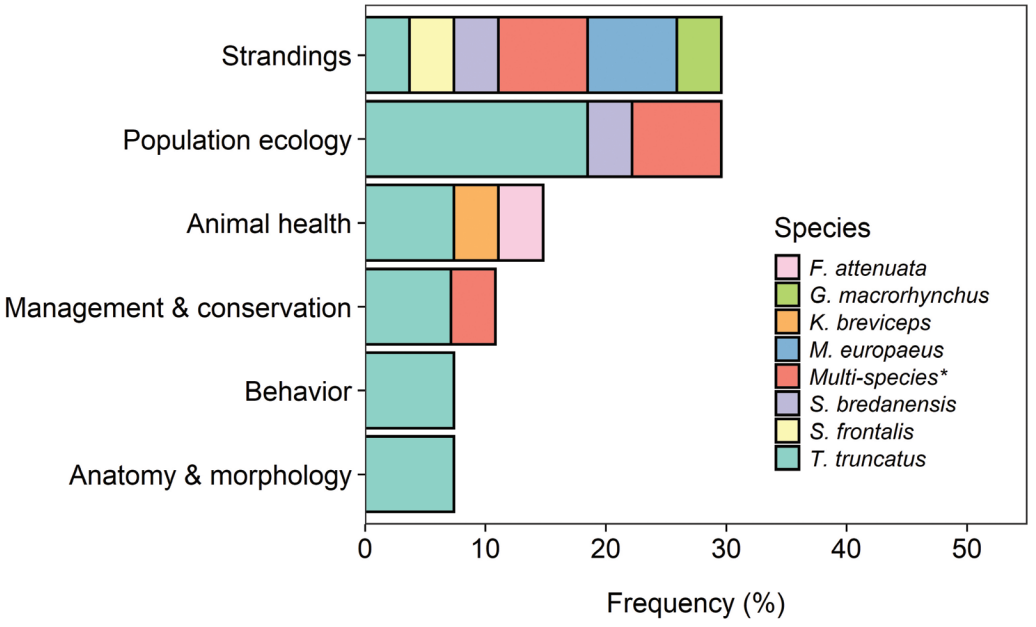

Figure 5. Proportion of scientific papers produced by Mexican institutions by topic and species during the period 1983 to 2017. *Indicates studies that include two or more species.

Discussion

Our chances of success in minimizing the negative impacts of human activities in particular areas depend primarily on our knowledge of how many species are present and how they are distributed in space and time (Kaschner et al., 2012). Research on the diversity, distribution, and abundance of cetaceans in the GOM began decades ago; however, our current knowledge about the state of their populations remains limited because although cetaceans in the U.S. EEZ have been surveyed extensively, the effort in Mexican waters has been poor. There are no comparative studies on the diversity of cetaceans along the latitudinal axis of the GOM, but it can be assumed that the number of species of odontocetes in the south (i.e., Mexican EEZ) should be the same as in the north (i.e., U.S. EEZ) and that stocks are likely transboundary (Waring et al., 2016). Observations from Ortega-Ortiz (2002), as well as ours, support this hypothesis: of the 20 species commonly sighted in the U.S. EEZ, there are 14 confirmed records in the Mexican EEZ.

No records of the pygmy sperm whale (*Kogia breviceps*), Blainville's beaked whale (*Mesoplodon densirostris*), striped dolphin (*Stenella coeruleoalba*), Cuvier's beaked whale (*Ziphius cavirostris*), and melon-headed whale (*Peponocephala electra*) were found. Nevertheless, this does not imply that these species are not distributed in Mexican waters but might be due to lack of survey effort, particularly in deep waters (> 1,000 m depth), which is their preferred habitat (Maze-Foley & Mullin, 2006; Würsig, 2017). This statement is supported by the fact that almost all georeferenced sightings compiled in this study were of bottlenose dolphins recorded in the continental shelf and the inner slope. The few sightings of the other species (and even of offshore bottlenose dolphins) have been recorded through isolated surveys conducted by different institutions and mostly in a non-systematic way. Hence, both archived and available data are minimal (i.e., existence and access to the data), which complicates their compilation and analysis.

The study of cetaceans in the U.S. EEZ began in the 1940s and initially had a descriptive approach, mainly publications on sightings and stranding reports (e.g., Gunter, 1946; Moore, 1953; Caldwell, 1955; Schmidly et al., 1972). In the last few decades, research has not only accelerated but has also diversified, and the current interest is aimed at identifying potential threats associated with anthropogenic activities (e.g., the effect of oil spills or noise pollution). A clear example is the increase in studies on animal health, mainly after the Deepwater Horizon oil spill in 2010 (e.g., Schwacke et al., 2017; Smith et al., 2017; Wallace et al., 2017). On the other hand, Mexican

research began in the 1980s, and its development has been extremely slow: average annual production has not increased; and in the 2010s, it was still similar to that of the U.S. in the 1980s (1.6 papers per year). Furthermore, until a few years ago, most publications were reports of strandings (e.g., Delgado-Estrella et al., 1998; Ortega-Argueta et al., 2005). Although the study topics seem to have diversified recently (e.g., González-Solís et al., 2006; Morteo et al., 2014), it is striking that all Mexican production in the 2010s was exclusively focused on a few coastal populations of bottlenose dolphins (e.g., Valdés-Arellanes et al., 2011; Vázquez-Castán et al., 2014; Morteo et al., 2017).

The low number of Mexican publications reflects the lack of interest of Mexican governmental and academic institutions in the cetaceans of the GOM. In the national context, investment in research infrastructure and human resources in the GOM is significantly lower compared to other regions such as the Gulf of California and the western coast of Baja California (Escobar-Lazcano, 2015), where there is a greater diversity of marine mammals (Torres et al., 1995). In the local context, the research of the academic institutions located in the GOM is focused on coastal populations of the bottlenose dolphin, ignoring offshore cetacean populations; and marine mammal conservation efforts promoted by government agencies have been directed exclusively to the endangered manatee (*Trichechus manatus*) (Muzquiz-Villalobos & Pompa-Mansilla, 2018).

Globally, cetaceans are affected by a wide range of threats, including the immediate and direct impacts of bycatch and, in some places, hunting, as well as the long-term impacts associated with habitat degradation, climate change, and loss of genetic diversity (Reeves et al., 2003). However, to determine the extent to which a particular threat impacts a population, it is essential to know its distribution, abundance, and population trend (Royle et al., 2014). Currently, the cetaceans of the GOM face different threats associated with human activities, mainly those related to the hydrocarbon industry, maritime traffic, and fisheries. Although population traits of several species are known in the U.S. EEZ, and although cetaceans have a transboundary distribution, the lack of data in the Mexican EEZ prevents the detection of changes in populations at the regional level. Therefore, to improve the knowledge about the status of cetacean populations in the GOM, it is necessary to invest in Mexican research capabilities and to establish large-scale and long-term binational monitoring and research programs.

Acknowledgments

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Literature Cited

Antochiw-Alonzo, D. M., & Manzano-Kantún, J. M. (2004, May). *Avistamientos de cetáceos en la plataforma de Yucatán* [Sightings of cetaceans in the Yucatan platform]. XXIX Reunión Internacional para el Estudio de los Mamíferos Marinos, La Paz, Baja California Sur, Mexico.

Burgin, C. J., Colella, J. P., Kahn, P. L., & Upham, N. S. (2018). How many species of mammals are there? *Journal of Mammalogy*, *99*(1), 1-14. https://doi.org/10.1093/jmammal/gyx147

Caldwell, D. K. (1955). Notes on the spotted dolphin, *Stenella plagiodon*, and the first record of the common dolphin, *Delphinus delphis*, in the Gulf of Mexico. *Journal of Mammalogy*, *36*(3), 467-470. https://doi.org/10.2307/1376541

Castro-Proal, G. (2018). *Distribución de delfínidos en las unidades de gestión ambiental de la costa occidental del golfo de México* [Delphinid distribution in the environmental management units of the west coast of the Gulf of Mexico] (Tesis de Maestria). Centro de Investigacion Cientifica y de Educacion Superior de Ensenada, Baja California, Mexico.

Delgado-Estrella, A. (2015). Patrones de residencia y movimientos a largo plazo de las toninas *Tursiops truncatus*, en la región sureste del Golfo de México [Residence patterns and long-term movements of dolphins *Tursiops truncatus*, in the southeastern Gulf of Mexico]. *Therya*, *6*(2), 297-314. https://doi.org/10.12933/therya-15-265

Delgado-Estrella, A., Villa, B., & Vázquez, L. E. (1998). First records of dwarf sperm whale (*Kogia breviceps*) pygmy sperm whale (*K. simus*) and pygmy killer whale (*Feresa attenuata*) in Veracruz, México. *Anales Del Instituto de Biología: Serie Zoología*, *69*(1), 129-134.

Díaz-Gamboa, R. E. (2015). Varamiento de orcas pigmeas (*Feresa attenuata* Gray 1874) en Yucatán: Reporte de caso [Stranding of pygmy killer whales (*Feresa attenuata* Gray 1874) in Yucatan: Case report]. *Bioagrociencias*, *8*(1), 36-43.

Escobar-Lazcano, M. J. (2015). *Análisis de tendencias y vacíos en la investigación de mamíferos marinos en México durante el periodo de 1988 al 2014* [Trends and

gaps analysis in marine mammal research in Mexico during the period 1988-2014] (Tesis de Licenciatura). Universidad Veracruzana, Veracruz, Mexico.

Felder, D. L., & Camp, D. K. (Eds.). (2009). *Gulf of Mexico origin, waters, and biota: Volume 1. Biodiversity*. Texas A&M University Press.

Fleiss, J. L. (1981). *Statistical methods for rates and proportions*. Wiley.

Galindo, J. A., Serrano, A., Vázquez-Castán, L., González-Gándara, C., & López-Ortega, M. (2009). Cetacean diversity, distribution, and abundance in northern Veracruz, Mexico. *Aquatic Mammals*, *35*(1), 12-18. https://doi.org/10.1578/AM.35.1.2009.12

González-Solís, D., Vidal-Martínez, V. M., Antochiv-Alonso, D. M., & Ortega-Argueta, A. (2006). Anisakid nematodes from stranded pygmy sperm whales, *Kogia breviceps* (Kogiidae), in three localities of the Yucatan Peninsula, México. *The Journal of Parasitology*, *92*(5), 1120-1122. https://doi.org/10.1645/GE-3553RN.1

Gunter, G. (1946). Records of the blackfish or pilot whale from the Texas coast. *Journal of Mammalogy*, *27*(4), 374-377. https://doi.org/10.2307/1375345

Heileman, S., & Rabalais, N. (2009). *XV-50 Gulf of Mexico: LME# 5* (The UNEP Large Marine Ecosystem Report). UNEP Regional Seas Report and Studies.

Hildebrand, J. A., Baumann-Pickering, S., Frasier, K. E., Trickey, J. S., Merkens, K. P., Wiggins, S. M., McDonald, M. A., Garrison, L. P., Harris, D., Marques, T. A., & Thomas, L. (2015). Passive acoustic monitoring of beaked whale densities in the Gulf of Mexico. *Scientific Reports*, *5*, 16343. https://doi.org/10.1038/srep16343

Jefferson, T. A., & Schiro, A. J. (1997). Distribution of cetaceans in the offshore Gulf of Mexico. *Mammal Review*, *27*(1), 27-50. https://doi.org/10.1111/j.1365-2907.1997.tb00371.x

Jefferson, T. A., Webber, M. A., & Pitman, R. L. (2015). *Marine mammals of the world: A comprehensive guide to their identification* (2nd ed.). Academic Press.

Karnauskas, M., Schirripa, M. J., Kelble, C. R., Cook, G. S., & Craig, J. K. (2013). *Ecosystem status report for the Gulf of Mexico* (NOAA Technical Memorandum NMFS-SEFSC-653). National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, U.S. Department of Commerce.

Kaschner, K., Quick, N. J., Jewell, R., Williams, R., & Harris, C. M. (2012). Global coverage of cetacean line-transect surveys: Status quo, data gaps and future challenges. *PLOS ONE*, *7*(9), e44075. https://doi.org/10.1371/journal.pone.0044075

Libiseller, C., & Grimvall, A. (2002). Performance of partial Mann–Kendall tests for trend detection in the presence of covariates. *Environmetrics: The Official Journal of the International Environmetrics Society*, *13*(1), 71-84. https://doi.org/10.1002/env.507

Maze-Foley, K., & Mullin, K. D. (2006). Cetaceans of the oceanic northern Gulf of Mexico: Distributions, group sizes and interspecific associations. *Journal of Cetacean Research and Management*, *8*(2), 203-213.

Moore, J. C. (1953). Distribution of marine mammals to Florida waters. *The American Midland Naturalist*, *49*(1), 117-158. https://doi.org/10.2307/2422283

Morteo, E., Rocha-Olivares, A., & Abarca-Arenas, L. G. (2014). Sexual segregation of coastal bottlenose dolphin (*Tursiops truncatus*) in the southwestern Gulf of Mexico. *Aquatic Mammals*, *40*(4), 375-385. https://doi.org/10.1578/AM.40.4.2014.375

Morteo, E., Rocha-Olivares, A., & Abarca-Arenas, L. G. (2017). Abundance, residency, and potential hazards for coastal bottlenose dolphins (*Tursiops truncatus*) off a productive lagoon in the Gulf of Mexico. *Aquatic Mammals*, *43*(3), 308-319. https://doi.org/10.1578/AM.43.3.2017.308

Muzquiz-Villalobos, M., & Pompa-Mansilla, S. (2018). Marine mammals of Mexico: Richness patterns, protected areas, and conservation trends. *Estuarine, Coastal and Shelf Science*, *208*, 153-160. https://doi.org/10.1016/j.ecss.2018.05.002

National Oceanic and Atmospheric Administration (NOAA). (2020). *Marine mammal stock assessments*. NOAA, U.S. Department of Commerce. https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-stock-assessments

Ortega-Argueta, A., Pérez-Sánchez, C. E., Gordillo-Morales, G., Gordillo, O. G., Pérez, D. G., & Alafita, H. (2005). Cetacean strandings on the southwestern coast of the Gulf of Mexico. *Gulf of Mexico Science*, *23*(2), 179. https://doi.org/10.18785/goms.2302.04

Ortega-Ortiz, J. G. (2002). *Multiscales analysis of cetacean distribution in the Gulf of Mexico* (Unpub. doctoral dissertation). Texas A&M University, College Station.

Ortega-Ortiz, J. G., Delgado-Estrella, A., & Ortega-Argueta, A. (2004). Mamíferos marinos del Golfo de México: Estado actual del conocimiento y recomendaciones para su conservación [Marine mammals of the Gulf of Mexico: Current knowledge and recommendations for their conservation]. In M. Caso, I. Pisanty, & E. Escurra (Eds.), *Diagnóstico ambiental del Golfo de México* [Environmental diagnosis of the Gulf of Mexico] (pp. 135-160). Instituto Nacional de Ecología.

R Core Team. (2018). R*: A language and environment for statistical computing*. R Foundation for Statistical Computing.

Reeves, R. R., Smith, B. D., Crespo, E. A., & Notarbartolo di Sciara, G. (2003). *Dolphins, whales, and porpoises: 2002-2010 Conservation action plan for the world's cetaceans*. IUCN/SSC Cetacean Specialist Group.

Royle, J. A., Chandler, R. B., Sollman, R., & Gerdner, B. (2014). *Spatial capture-recapture*. Academic Press. https://doi.org/10.1016/B978-0-12-405939-9.00005-0

Schmidly, D. J., & Würsig, B. (2009). Mammals (Vertebrata: Mammalia) of the Gulf of Mexico. In D. L. Felder & D. K. Camp (Eds.), *Gulf of Mexico origin, waters, and biota: Volume 1. Biodiversity* (pp. 1343-1352). Texas A&M University Press. https://doi.org/10.2307/1379060

Schmidly, D. J., Beleau, M. H., & Hildebran, H. (1972). First record of Cuvier's dolphin from the Gulf of Mexico with comments on the taxonomic status of *Stenella frontalis*. *Journal of Mammalogy*, *53*(3), 625-628. https://doi.org/10.2307/1379060

Schwacke, L. H., Thomas, L., Wells, R. S., McFee, W. E., Hohn, A., Mullin, K. D., Zolman, E. S., Quigley, B. M., Rowles, T. K., & Schwacke, J. H. (2017). Quantifying injury to common bottlenose dolphins from the Deepwater Horizon oil spill using an age-, sex- and class-structured population model. *Endangered Species Research*, *33*, 265-279. https://doi.org/10.3354/esr00777

Smith, C. R., Rowles, T. K., Hart, L. B., Townsend, F. I., Wells, R., Zolman, E. S., Balmer, B. C., Quigley, B., Ivančić, M., McKercher, W., Tumlin, M. C., Mullin, K. D., Adams, J. D., Wu, Q., McFee, W., Collier, T. K., & Schwacke, L. H. (2017). Slow recovery of Barataria Bay dolphin health following the Deepwater Horizon oil spill (2013-2014), with evidence of persistent lung disease and impaired stress response. *Endangered Species Research*, *33*, 127-142. https://doi.org/10.3354/esr00778

Soldevilla, M. S., Hildebrand, J. A., Frasier, K. E., Aichinger-Dias, L., Martinez, A., Mullin, K. D., Rosel, P. E., & Garrison, L. P. (2017). Spatial distribution and dive behavior of Gulf of Mexico Bryde's whales: Potential risk of vessel strikes and fisheries interactions. *Endangered Species Research*, *32*, 533-550. https://doi.org/10.3354/esr00834

Torres, A., Esquivel, C., & Ceballos, G. (1995). Diversidad y conservación de los mamíferos marinos de México [Diversity and conservation of Mexico's marine mammals]. *Revista Mexicana de Mastozoología*, *1*, 22-43. https://doi.org/10.22201/ie.20074484e.1995.1.1.157

Valdés-Arellanes, M. P., Serrano, A., Heckel, G., Schramm, Y., & Martínez-Serrano, I. (2011). Abundancia de dos poblaciones de toninas (*Tursiops truncatus*) en el norte de Veracruz, México [Abundance of two populations of bottlenose dolphins (*Tursiops truncatus*) in northern Veracruz, Mexico]. *Revista Mexicana de Biodiversidad*, *82*(1), 227-235. https://doi.org/10.22201/ib.20078706e.2011.1.367

Vázquez-Castán, L., Serrano, A., & Galindo, J. A. (2009). Estudio preliminar sobre la diversidad, distribución y abundancia de cetáceos en aguas profundas del Golfo de México [Preliminary study on the diversity, distribution and abundance of cetaceans in deep waters of the Gulf of Mexico]. *Revista UDO Agrícola*, *9*(4), 992-997.

Vázquez-Castán, L., Serrano, A., López-Ortega, M., Galindo, J. A., Díaz-Arredondo, M. A., & Capistran-Barradas, A. (2014). Is the northern-central coast of Veracruz, Mexico an important area for bottlenose dolphins (*Tursiops truncatus* Montagu, 1821)? *Thalassas*, *30*(2), 57-64.

Wallace, B. P., Brosnan, T., McLamb, D., Rowles, T., Ruder, E., Schroeder, B., Schwacke, L., Stacy, B., Sullivan, L., Takeshita, R., & Wehner, D. (2017). Effects of the Deepwater Horizon oil spill on protected marine species. *Endangered Species Research*, *33*, 1-7. https://doi.org/10.3354/esr00789

Waring, G. T., Josephson, E., Maze-Foley, K., & Rosel, P. E. (2016). *U.S. Atlantic and Gulf of Mexico marine mammal stock assessments—2015* (NOAA Technical Memorandum NMFS-NE-238). National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

Wickham, H. (Ed.). (2010). *ggplot2: Elegant graphics for data analysis (Use* R*!)*. Springer.

Wilson, K. A., Auerbach, N. A., Sam, K., Magini, A. G., Moss, A. St. L., Langhans, S. D., Budiharta, S., Terzano, D., & Meijaard, E. (2016). Conservation research is not happening where it is most needed. *PLOS Biology*, *14*(3), e1002413. https://doi.org/10.1371/journal.pbio.1002413

Würsig, B. (2017). Marine mammals of the Gulf of Mexico. In C. H. Ward (Ed.), *Habitats and biota of the Gulf of Mexico: Before the Deepwater Horizon oil spill: Volume 2. Fish resources, fisheries, sea turtles, avian resources, marine mammals, diseases and mortalities* (pp. 1489-1588). Springer Open. https://doi.org/10.1007/978-1-4939-3456-0_5