OIL SPILL SCIENCE
SEA GRANT PROGRAMS OF THE GULF OF MEXICO

THE SEA GRANT and GOMRI PARTNERSHIP

The mission of Sea Grant is to enhance the practical use and conservation of coastal, marine and Great Lakes resources in order to create a sustainable economy and environment. There are 33 university-based Sea Grant programs throughout the coastal U.S. These programs are primarily supported by the National Oceanic and Atmospheric Administration and the states in which the programs are located.

In the immediate aftermath of the Deepwater Horizon spill, BP committed $500 million over a 10-year period to create the Gulf of Mexico Research Initiative, or GoMRI. It is an independent research program that studies the effect of hydrocarbon releases on the environment and public health, as well as develops improved spill mitigation, oil detection, characterization, and remediation technologies. GoMRI is led by an independent and academic 20-member research board.

The Sea Grant oil spill science outreach team identifies the best available science from projects funded by GoMRI and others, and only shares peer-reviewed research results.

Sea Grant
Texas • Louisiana • Florida
Mississippi-Alabama

gulfseagrant.org

GULF OF MEXICO RESEARCH INITIATIVE

gulfresearchinitiative.org

THE DEEPWATER HORIZON OIL SPILL'S IMPACT ON BOTTLENOSE DOLPHINS

Larissa Graham, *Christine Hale, Emily Maung-Douglass, Stephen Sempier, Tara Skelton, LaDon Swann, and Monica Wilson*

After the Deepwater Horizon oil spill, the public worried that the oil spill caused health problems in bottlenose dolphins in the Gulf of Mexico. Scientists examined the health and stranding patterns of dolphins along the coasts of Louisiana, Mississippi, and Alabama and discovered oiled areas had more sick and dead dolphins than other areas.

Young bottlenose dolphins died in areas affected by the 2010 Deepwater Horizon oil spill. Unborn dolphins from the northern Gulf Coast were 18 times more likely to show signs of fetal distress than those from the other areas. (NOAA)

OIL AND ITS IMPACT ON DOLPHINS

The Deepwater Horizon oil spill occurred on April 20, 2010. The ruptured wellhead released approximately 172 million gallons of oil into Gulf of Mexico waters before responders capped it on July 19, 2010. Emergency responders used **dispersants** to break up oil at the sea surface and at the wellhead located almost a mile below the surface of the water.[1-5]

Marine mammals, like dolphins and whales, breathe air at the surface of the

water where oil slicks form during spills. The oil and its vapors can irritate and damage their airways and lungs. Marine mammals may also be exposed to oil by eating contaminated prey or ingesting oil from the water or sediments when feeding.[6]

Chemicals in oil can make marine mammals sick depending on the amount and type of oil animals are exposed to, how long they are exposed, and how healthy they are at the time of exposure. Their livers can break down some chemicals in oil. However, some of these chemicals can be toxic if they are present in high amounts.[6,7] Chemicals in oil can also cause harm that can make animals sick over time. Exposure to chemicals can weaken their immune systems, making it harder to fight off disease or parasites.[8] Oil contaminants can also affect their food supply if oil causes prey to become sick or die. There may be less food available or food may be of poorer quality.[10]

TROUBLE FOR MARINE MAMMALS ALONG THE NORTHERN GULF COAST

In 2010, scientists documented an increased number of stranded **cetaceans**, or dolphins and whales, along the northern Gulf of Mexico (Figure 1, Table 1). Experts declared the deaths were part of an **unusual mortality event**. An unusual mortality event occurs when there is an unexpected increase in **stranded** marine mammals. These events demand an immediate response and investigation. Understanding the cause of a die-off is important because marine mammals can serve as indicators of ocean health and provide insight into larger environmental issues. Many marine mammals are long-lived and slow to mature. Dolphins, for example, can live for 40 to 50 years. The death of even a few individuals can have a large impact on the overall population.[9]

Scientists began studying bottlenose dolphins and their populations along the Gulf Coast in response to the 2010 die-off.[9-17] Experts determined the unusual mortality event began a month before the oil spill when especially cold temperatures caused dolphins to strand along the coasts of Louisiana and Mississippi.[10] However, the largest increase in stranded cetaceans occurred in oiled areas following the Deepwater Horizon spill.[13]

After the oil spill, natural resource trustees assessed its impact on coastal and marine natural resources through the **Natural Resource Damage Assessment (NRDA)** process (Table 2). This process examined how the oil spill impacted marine mammals in the northern Gulf of Mexico.[17] They determined that the oil spill was the main cause of the increase in dolphin deaths in the northern Gulf using data they collected through the NRDA process, the unusual mortality

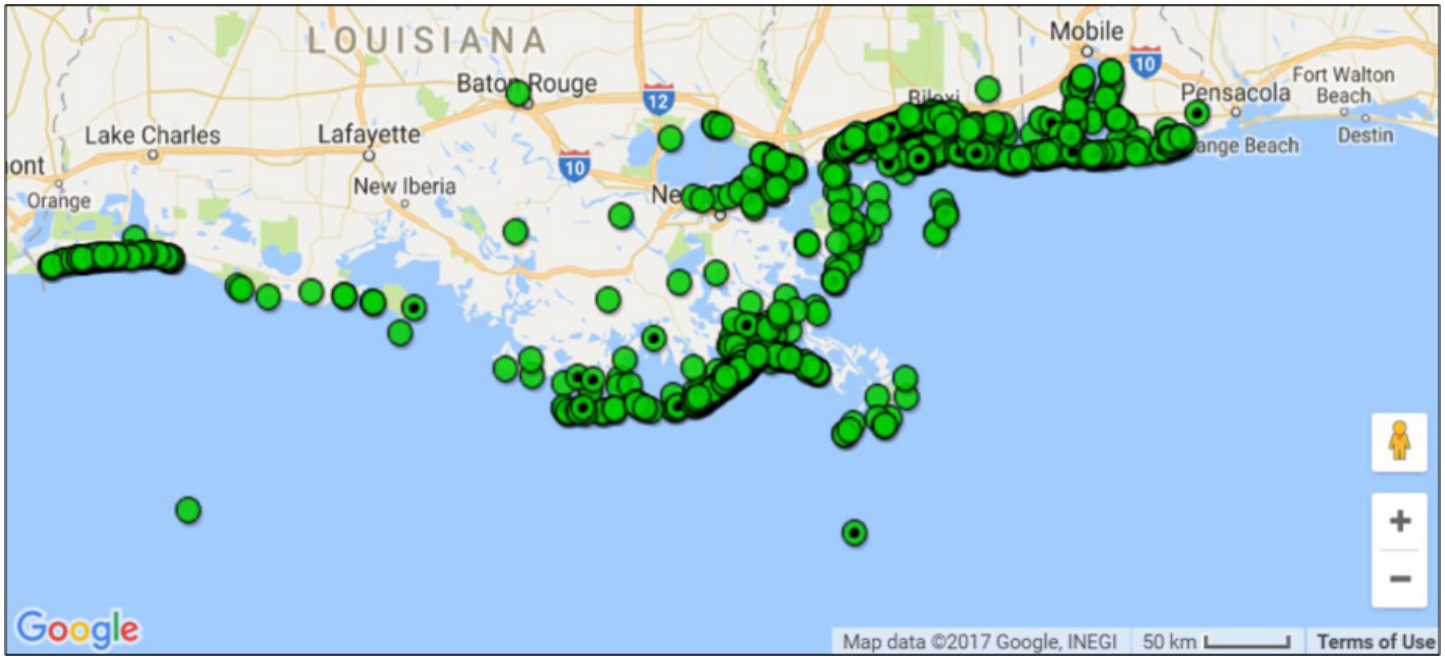

FIGURE 1: *Bottlenose dolphins, represented by green dots, stranded in many locations in Louisiana, Mississippi, and Alabama between 2010 and 2014. The circles with dots represent perinatal dolphins, shorter than 45 inches long. This map can be accessed at* ***http://www.nmfs.noaa.gov/pr/health/mmume/cetacean_gulfofmexico.htm*** *and was last updated in May 2016.[9] (NOAA)*

LARGE MARINE MAMMAL LOSSES FOLLOWING THE DEEPWATER HORIZON OIL SPILL

Location	Historical average number of stranded dolphins and whales each year by state	Mar - Dec 2010 (10 months)	2011 (12 months)	2012 (12 months)	2013 (12 months)	Jan - Jul 2014 (7 months)	Total number of strandings by state during the usual mortality event
Alabama	14	21	59	30	27	32	169
Mississippi	20	63	111	50	51	43	318
Louisiana	21	135	164	94	147	74	614
Total by year	**55**	**219**	**334**	**174**	**225**	**149**	**1,101**

TABLE 1. *A number of dolphins and whales stranded along the Louisiana, Alabama, and Mississippi coastlines during the unusual mortality event. Strandings peaked in 2011, which scientists believe was partly due to the Deepwater Horizon oil spill.*[9]

Bottlenose dolphin stock	Estimate of population with adverse health effects	Estimate of population that died	Estimate of maximum decrease in population	Estimate years for population to recover
Barataria Bay (LA)	37%	35%	51%	39
Mississippi River Delta (MS)	37%	59%	71%	52
Mississippi Sound (MS)	24%	22%	62%	46
Mobile Bay (AL)	24%	12%	31%	31

TABLE 2. *Scientists studied different dolphin populations around the Gulf of Mexico to access injury from the Deepwater Horizon oil spill for the Natural Resources Damage Assessment process.*[17]

event investigation, and other research. They also suggested that oil exposure led to reproductive failure, sickness, and death in dolphins living within the oil spill footprint.[9,17] Experts declared the unusual mortality event closed as of July 2014 when the number of stranded cetaceans began to decrease. This event was the longest known marine mammal die-off in the Gulf of Mexico.[9]

THE NORTHERN GULF OF MEXICO MARINE MAMMAL DIE-OFF

Responders reported more than 1,000 stranded cetaceans along the coasts of Louisiana, Mississippi, and Alabama during the unusual mortality event. Some scientists believe the actual number of marine mammals that died is much higher than reported. Cetaceans that died in remote areas and deeper waters may not have been found because they did not strand.[17,18] Those that die offshore are much less likely to strand than animals found in coastal waters.[18]

Of the 95 percent of stranded cetaceans found dead, more than 80 percent were bottlenose dolphins.[9,11] Many of the dolphins were adults. However, responders also found a large number of **perinatal** dolphins. The number of stranded perinatal dolphins found in Mississippi and Alabama in the winter of 2011 was much higher than in previous years.[12] Scientists discovered 769 bottlenose dolphins stranded along the coasts of Louisiana, Mississippi, and Alabama between January 2010 and December 2013. Of these, 22 percent were perinatal dolphins.[10,12]

DEEPWATER HORIZON'S IMPACT

Scientists believe that oil exposure during the spill caused health problems in Gulf Coast dolphins. They examined the time of year, location, and number of stranded dolphins along the coasts of Louisiana, Mississippi, and Alabama to see if areas that received more oiling had a greater number of dead dolphins. Dolphins living in areas affected by the spill were more likely to be ill. The poor health conditions of dolphins in heavily oiled areas were similar to conditions scientists have found when they expose animals to oil in the laboratory.[15,17,19,20] In contrast, the coasts of Florida and Texas, where there was little or no oiling, did not have an increase in stranded bottlenose dolphins after the oil spill.[11,13,16]

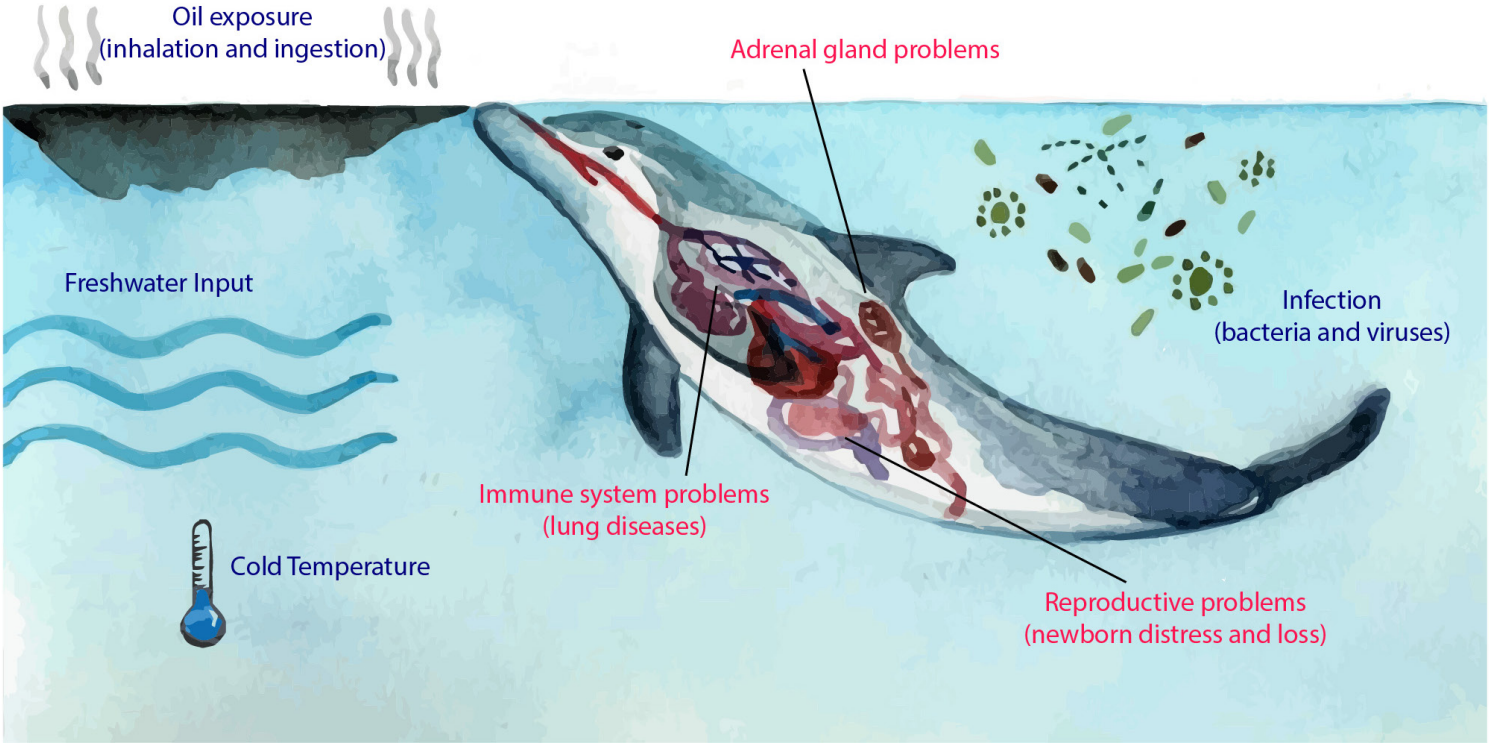

FIGURE 2: *Many factors impacted bottlenose dolphins and led to high numbers of strandings along the northern Gulf of Mexico. Experts have determined that the increase of sick and dead dolphins was due, in part, to the Deepwater Horizon oil spill. (Florida Sea Grant/Anna Hinkeldey)*

Breathing in fumes from oil slicks and possibly ingesting oil when feeding may have weakened dolphins' immune systems, making it harder for them to fight off diseases and infections.[8] The most common cause of death during between June 2010 and December 2012 was infectious diseases, such as bacterial pneumonia. Dolphins living in oiled areas in the northern Gulf were four times more likely to die from infections than dolphins stranded elsewhere.[16]

A combination of stressors, including the oil spill, may have also caused the high number of perinatal deaths in 2011. Perinatal dolphins that stranded along the coasts of Mississippi and Alabama in 2011 were eight times more likely to have pneumonia or inflamed lungs compared to perinatal dolphins from non-oiled sites in South Carolina and Florida. These dolphins were also 18 times more likely to show signs of fetal distress than those from areas outside the region. They were shorter in size, on average, compared to stranded dolphins from previous years. Scientists think this is because they died before they were born. They also think that cold and freshwater runoff prior to and following the oil spill may have affected pregnant female dolphins.[10,12]

Scientists studied dolphin populations in Barataria Bay in Louisiana, the Mississippi River Delta and the Mississippi Sound in Mississippi, and Mobile Bay in Alabama for the NRDA process. They observed dolphins in the field and used computer models to determine the impact that the oil spill had on the dolphins living in these areas (Table 2). Scientists believe that dolphin populations in these areas declined from 30 to 70 percent and could take 30 to 50 years to recover.[17]

DOLPHINS IN A HEAVILY OILED AREA WERE SICKER THAN DOLPHINS IN OTHER AREAS

Heavy oiling occurred in Barataria Bay during the spill. Responders observed dolphins swimming through and feeding in visibly oiled waters. These dolphins may have encountered higher amounts of oil over a longer time period than dolphins in other areas.

Following the oil spill, scientists collected a lot of information about the dolphins in Barataria Bay. They tested the blood, skin, and blubber tissue and obtained the age, weight, and length of live dolphins. They also performed ultrasound examinations of the

lungs to check for sicknesses, such as pneumonia. Scientists did not have any data for dolphins in this area before the spill, so they conducted the same health assessment for dolphins in Sarasota Bay, Florida, because it was not oiled by the spill. They found that dolphins in Barataria Bay were more likely to be ill and had many health conditions not found in Sarasota Bay dolphins.[19,20]

Barataria Bay dolphins had excessive tooth loss and were in poor condition. Twenty-five percent of dolphins studied were underweight. These dolphins were also five times more likely to have lung problems, with many having moderate to severe lung disease. Dolphins in Barataria Bay had **adrenal glands** that were not working properly. Adrenal glands are important because they help dolphins respond to stress and control blood pressure.[19,20] The lung and adrenal gland problems in live dolphins corresponded to abnormalities found in the dead dolphins from oiled sites.[16] Also, only 20 percent of pregnant dolphins that scientists saw had live young following their due dates. In healthy dolphin populations, about 83 percent of pregnancies typically result in the birth of live calves.[15]

Scientists gave nearly half of the Barataria Bay dolphins a bad prognosis, indicating these animals were sick. There was a high rate of deaths in the adult dolphins in this area. In one study, scientists estimated that 17 percent of dolphins that they observed would die based on their condition. In another study, 14 percent of the dolphins died before the study was completed. This rate of death is about three times higher than typically observed in healthy populations of dolphins. [15,19,20]

Experts predict that the oil spill reduced the population of bottlenose dolphins in Barataria Bay by as much as half. Scientists estimate it could take this population nearly 40 years to recover.[17]

The numbers of dolphin deaths may seem alarming. However, scientists cannot say how alarming because they do not have baseline data about the health of Barataria Bay dolphins before the spill. Baseline data serves as a starting point to allow scientists to determine how much something has changed over time or after an event. The lack of baseline data in Barataria Bay limits the full understanding of the extent that the oil spill affected dolphin populations. It is possible dolphins in Barataria Bay were in a different or poorer condition even before the oil spill.

TEASING OUT OTHER FACTORS THAT CAUSED DOLPHIN DEATHS

An increase in dolphin strandings occurred primarily along the coasts of Lake Pontchartrain in Louisiana and western Mississippi in March through May 2010. So what was the cause of the deaths during this time? Scientists believe that prolonged exposure to low salinity and cold temperature in these areas resulted in dolphin deaths.[11,17] They also believe that the changes to temperature and **salinity** may have affected the dolphins' habitat and food sources.[10]

Scientists retrieved this dead dolphin from Grand Isle Beach, Louisiana, in January 2012. The visible ribs and depressions along the back are signs of extreme weight loss. (LDWF)

The largest, most prolonged cluster of stranded dolphins occurred one year after the spill. This die-off included a large number of perinatal dolphins found along the Mississippi and Alabama coasts. Scientists believe that oil exposure made pregnant dolphins more susceptible to infection. They also believe that exposure to contaminants in the womb may have caused perinatal dolphins to die. The cold winter and freshwater from inland snow melt may have also contributed to the timing and location of these strandings.[10] Marine mammal strandings typically do increase during cold, winter months.[9] However, scientists do not believe cold weather alone caused health problems found in sick and stranded dolphins in 2011. It is possible that dolphins were more susceptible to sickness or death because of their exposure to cold temperatures.[14]

Scientists also wondered how bacterial and viral infections affected dolphin health. Some dolphins tested positive for the bacteria **Brucella**, which can cause poor health in dolphins. *Brucella* does not typically cause mass die-offs, but it can cause late-term miscarriages in dolphins. **Morbillivirus** is a viral disease often linked to unusual mortality events in marine mammals but rarely found in stranded dolphins during and after the oil spill.

The amount of *Brucella* and morbillivirus in dolphins in oiled waters was similar to levels found before the spill and in adult dolphins outside of the northern Gulf of Mexico. Scientists found higher levels of *Brucella* in perinatal dolphins in Mississippi Sound compared to dolphins from non-oiled waters. These scientists believe the oil affected the pregnant dolphins' immune systems, making them more suseptible to infections.[12] For all of these reasons, scientists believe that *Brucella* or morbillivirus may have contributed to but was not the main cause of death for young and adult dolphins that have stranded during the Gulf of Mexico unusual mortality event.[11,13-16]

SCIENTISTS TAKE THE NEXT STEP

The unusual mortality event is closed, but it does not mean that the effects of oil on these marine mammal populations have ended. Scientists continue to study dolphin populations throughout the Gulf of Mexico and monitor the long-term health effects of the oil spill.

Scientists measure a healthy 21-year-old adult male during a dolphin health assessment in Sarasota Bay, Florida. Scientists studied dolphins in this area to provide a comparison because Sarasota Bay did not receive Deepwater Horizon oil. (NOAA)

Bottlenose dolphins are one of many marine mammals being studied post-oil spill. Scientists are collecting data on 21 different types of whales and other dolphins that live in the Gulf of Mexico, including the beaked whale and the endangered sperm whale. Scientists use acoustic monitoring to estimate population sizes of some marine mammals because they live in deep water and are harder to study.

GLOSSARY

Adrenal gland — The two adrenal glands are located above each kidney and help regulate hormones, particularly during times of stress.

Brucella — A type of bacteria that has been known to infect dolphins, as well as other animals, and can cause abortion, brain infection, pneumonia, and skin and bone infections.

Cetacean — A large aquatic mammal, such as a whale, dolphin, or porpoise, that has a torpedo-shaped nearly hairless body, paddle-shaped forelimbs but no hind limbs, blowholes for breathing, and a horizontally flattened tail used to swim.

Dispersant — Chemicals that are used during oil spill response efforts to break up oil slicks and can limit floating oil from impacting sensitive ecosystems, such as coastal habitats.

Marine mammal — A diverse group of mammals that rely on the ocean for their existence.

Morbillivirus — A group of viruses that can infect humans, dogs, cattles, and cetaceans and cause illnesses, such as fever and rash in humans and respiratory tract infections in animals.

Natural Resource Damage Assessment (NRDA) — The legal process used to determine the impacts of oil spills, hazardous waste sites, and ship groundings on natural resources and humans.

Perinatal — The period around the time of birth, usually a number of weeks immediately before and after birth.

Salinity — The average concentration of dissolved salts in a body of water.

Stranded — Any dead marine mammal on shore or in the water or any live marine mammal washed ashore, unable to return to its natural habitat, or in need of medical attention.

Unusual mortality event — A stranding event where many marine mammals die, sometimes for reasons unknown, and immediate response is needed. These events are defined in the Marine Mammal Protection Act, which lawmakers created in 1972 because of scientific and public concern that human activity was causing large declines in marine mammal populations.

REFERENCES

1. Griffiths, S. K. (2012). Oil release from Macondo Well MC252 following the Deepwater Horizon accident. *Environmental Science and Technology, 46*(10), 5616-5622.
2. Lehr, B., Bristol, S., Possolo, A., Bai, X., Wang, J., Sellinger, C., ... & Assel, R. (2010). *Oil budget calculator Deepwater Horizon: Technical documentation. A Report by the Federal Interagency Solutiong Group, Oil Budget Calculator Science and Engineering Team*.
3. National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. (2010). *The use of surface and subsea dispersants during the BP Deepwater Horizon oil spill, Staff Working Paper No. 4.* Retrieved from http://permanent.access.gpo.gov/gpo184/Working%20Paper.Dispersants.For%20Release.pdf
4. Coastal Response Research Center, Research Planning Incorporated, and National Oceanic Atmospheric Administration. (2012). *The future of dispersant use in oil spill response initiative.* Retrieved from http://crrc.unh.edu/sites/crrc.unh.edu/files/media/docs/Workshops/dispersant_future_11/Dispersant_Initiative_FINALREPORT.pdf
5. US Coast Guard. (2011). *On Scene Coordinator Report Deepwater Horizon Oil Spill: Submitted to the National Response Team, September 2011.* Retrieved from https://www.uscg.mil/foia/docs/DWH/FOSC_DWH_Report.pdf
6. Gubbay, S. & Earll, R. (2000). Review of literature on the effects of oil spills on cetaceans *Scottish Natural Heritage Review,* (3), 1-34.
7. Engelhardt, F. R. (1983). Petroleum effects on marine mammals. *Aquatic Toxicology, 4*(3), 199-217.
8. Barron, M. G. (2012). Ecological impacts of the Deepwater Horizon oil spill: Implications for immunotoxicity. *Toxicologic Pathology, 40*(2), 315-320.
9. National Oceanic and Atmospheric Administration Fisheries. (2016). *Cetacean unusual mortality event in northern Gulf of Mexico (2010-present).* Retrieved from http://www.nmfs.noaa.gov/pr/health/mmume/cetacean_gulfofmexico.htm
10. Carmichael, R. H., Graham, W. M., Aven, A., Worthy, G., & Howden, S. (2012). Were multiple stressors a "perfect storm" for northern Gulf of Mexico bottlenose dolphins (*Tursiops truncatus*) in 2011? *PLoS ONE, 7*(7), e41155.
11. Litz, J. A., Baran, M. A., Bowen-Stevens, S. R., Carmichael, R. H., Colegrove, K. M., Garrison, L. P., ... & Rowles, T. K. (2014). Review of historical unusual mortality events (UMEs) in the Gulf of Mexico (1990-2009): Providing context for the multi-year northern Gulf of Mexico cetacean UME declared in 2010. *Diseases of Aquatic Organisms, 112*(2), 161-175.
12. Colegrove, K. M., Venn-Watson, S., Litz, J., Kinsel, M. J., Terio, K. A., Fougeres, ... & Rowles, T. K. (2016). Fetal distress and *in utero* pneumonia in perinatal dolphins during the Northern Gulf of Mexico unusual mortality event. *Diseases of Aquatic Organisms, 119*(1), 1-16.
13. Venn-Watson, S., Garrison, L., Litz, J., Fougeres, E., Mase, B., Rappucci, G., ... & Rowles, T. (2015). Demographic Clusters Identified within the Northern Gulf of Mexico Common Bottlenose Dolphin (*Tursiops truncates*) Unusual Mortality Event: January 2010 – June 2013. *PLOS ONE, 10*(2), e0117248.
14. Venn-Watson, S., Colegrove, K. M., Litz, J., Kinsel, M., Terio, K., Saliki, J., ... & Rowles, T. (2015). Morbidity and mortality in bottlenose dolphins: Summary of alternative hypotheses. DWH NRDA Marine Mammal Techincal Working Group Report. Retrieved from *https://pub-dwhdatadiver.orr.noaa.gov/dwh-ar-documents/876/DWH-AR0105930.pdf*

15. Lane, S. M., Smith, C. R., Mitchell, J., Balmer, B. C., Barry, K. P., McDonald, T., ... & Townsend, F. I. (2015, November). Reproductive outcome and survival of common bottlenose dolphins sampled in Barataria Bay, Louisiana, USA, following the Deepwater Horizon oil spill. In Proc. R. Soc. B (Vol. 282, No. 1818, p. 20151944). The Royal Society.

16. Venn-Watson, S., Colegrove, K. M., Litz, J., Kinsel, M., Terio, K., Saliki, J., ... & Rowles, T. (2015). Adrenal gland and lung lesions in Gulf of Mexico common bottlenose dolphins (*Tursiops truncatus*) found dead following the Deepwater Horizon oil spill. *PLOS ONE, 10*(5), e0126538.

17. Deepwater Horizon Natural Resource Damage Assessment Trustees. (2016). Deepwater Horizon oil spill: Final Programmatic Damage Assessment and Restoration Plan and Final Programmatic Environmental Impact Statement. Retrieved from *http://www.gulfspillrestoration.noaa.gov/restoration-planning/gulf-plan*

18. Williams, R., Gero, S., Bejder, L., Calambokidis, J., Kraus, S. D., Lusseau, D., ... & Robbins, J. (2011). Underestimating the damage: Interpreting cetacean carcass recoveries in the context of the Deepwater Horizon/BP incident. *Conservation Letter, 4*(3), 228-233.

19. Schwacke, L. H., Smith, C. R., Townsend, F. I., Wells, R. S., Hart, L. B., Balmer, B. C., ... & Lamb, S. V. (2013). Health of common bottlenose dolphins (*Tursiops truncatus*) in Barataria Bay, Louisiana, following the Deepwater Horizon oil spill. *Environmental Science and Technology, 48*(1), 93-103.

20. Smith, C. R., Townsend, F. I., Rowles, T. K., Hart, L. B., Zolman, E. S., Wells, ... Schwacke, L. H. (2015). Health data and prognosis determination of live bottlenose dolphin (*Tursiops truncatus*) examined in the aftermath of the Deepwater Horizon oil spill. DWH NRDA Marine Mammal Technical Working Group Report. Retrieved from https://pub-dwhdatadiver.orr.noaa.gov/dwh-ar-documents/876/DWH-AR0105938.pdf

More information about some of these ongoing studies is available on Gulf of Mexico Research Initiative's website at http://gulfresearchinitiative.org.

To learn about impacts to dolphin populations reported by the Natural Resource Damage Assessment, visit http://www.gulfspillrestoration.noaa.gov/affected-gulf-resources/.

Additional publications focusing on dispersants, impacts to fisheries and habitats, and other topics are on the Sea Grant Oil Spill Science Outreach Program website at www.gulfseagrant.org/oilspilloutreach.

To report a stranded marine animal, visit http://www.nmfs.noaa.gov/pr/health/report.htm.

To access state stranding information or to download the Dolphin & Whale 911 application for your phone, visit http://sero.nmfs.noaa.gov/protected_resources/outreach_and_education/mm_apps/.

SUGGESTED CITATION

Suggested citation: Graham, L., Hale, C., Maung-Douglass, E., Sempier, S., Skelton, T., Swann, L., and Wilson, M. (2017). Oil spill science: The Deepwater Horizon oil spill's impact on bottlenose dolphins. MASGP-17-002.

OIL SPILL SCIENCE OUTREACH TEAM

Christine Hale
Texas Sea Grant College Program
chris.hale@tamu.edu

Larissa Graham
Mississippi-Alabama Sea Grant Consortium
larissa.graham@auburn.edu

Emily Maung-Douglass
Louisiana Sea Grant College Program
edouglass@lsu.edu

Stephen Sempier
Mississippi-Alabama Sea Grant Consortium
stephen.sempier@usm.edu

Tara Skelton
Mississippi-Alabama Sea Grant Consortium
tara.skelton@usm.edu

LaDon Swann
Mississippi-Alabama Sea Grant Consortium
swanndl@auburn.edu

Monica Wilson
Florida Sea Grant, UF/IFAS Extension
monicawilson447@ufl.edu

Sea Grant
Texas • Louisiana • Florida
Mississippi-Alabama

GULF OF MEXICO RESEARCH INITIATIVE

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE

This work was made possible in part by a grant from The Gulf of Mexico Research Initiative, and in part by the Sea Grant programs of Texas, Louisiana, Florida and Mississippi-Alabama. The statements, findings, conclusions and recommendations do not necessarily reflect the views of these organizations.

MASGP-17-002 GOMSG-G-17-002