Oil and Sea Turtles

BIOLOGY, PLANNING, AND RESPONSE

August 2021

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration • National Ocean Service • Office of Response and Restoration

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Table of Content

Acknowledgments 1

Introduction 3

Chapter 1. Sea Turtle Biology and Life History 5

- Key Points **5**
- Introduction: What Is a Sea Turtle? **6**
- Sea Turtle Species and Their Conservation Status **7**
- Sea Turtle Life History **11**
- General Behavioral and Physiological Traits of Sea Turtles **14**
- Species Descriptions **17**
- For Further Reading **24**

Chapter 2. Natural and Human Threats to Sea Turtles 27

- Key Points **27**
- Introduction **28**
- Natural Mortality Factors **29**
- Anthropogenic Mortality Factors **32**
- Further Reading **38**

Chapter 3. Oil Exposure and Effects on Sea Turtles 41

- Key Points **41**
- Introduction **42**
- Where are sea turtles exposed to oil? **43**
- Adverse effects of oil on sea turtles **46**
- Further Reading **49**

Chapter 4. Response Considerations for Sea Turtles 53

- Key Points **53**
- Introduction and Background **54**
- Sea Turtle Response and the Incident Command System (ICS) **57**
- Exposure and Risk: Planning and Assessment **59**
- Overview of Open-Water Response Methods **61**
- *Sargassum spp.* as a response consideration and concern **68**
- Overview of Shoreline Cleanup Methods **70**
- Anticipating the Consequences of Response **76**

Direct intervention for oiled sea turtles and nests **77**
For Further Reading **82**

Chapter 5. Oil Spill Trends and Case Histories of Incidents Affecting Sea Turtles 85

Key Points **85**
Spills that Threaten Sea Turtles **86**
Background: Facts, Figures, and Trends in U.S. and Global Oil Spills **89**
Case Studies **92**
For Further Reading **112**

Acronyms 117

Appendix A: Memorandum of Understanding A-1

Appendix B: Best Management Practices B-1

Appendix C: Examples of Best Management Practices to Protect Sea Turtles During Response Operations C-1

Appendix D: Temporal presence of different life stages (adults, juveniles, hatchlings) for each species in each U.S. region D-1

Table of Figures

Figure 1.1. Sea turtle species found in U.S. waters **7**

Figure 1.2. Guide to sea turtles found in United States territorial waters **8**

Figure 1.3. Generalized sea turtle lifestyle **12**

Figure 1.4. Kemp's ridley turtle laying eggs at South Padre Island, Texas **13**

Figure 1.5. Aerial view of arribada of Kemp's ridley turtles at Rancho Nuevo, Mexico **14**

Figure 1.6. Loggerhead turtle (*Caretta caretta*) hatchlings emerging from a nest in the Florida Keys, July 2014 **14**

Figure 1.7. A juvenile green turtle (*Chelonia midas*) in *Sargassum* **14**

Figure 1.8. Tracks showing a non-nesting haulout in the Archie Carr National Wildlife Refuge, Florida, June 2009 **15**

Figure 1.9. Loggerhead turtle (*Caretta caretta*) **17**

Figure 1.10. Juvenile loggerhead turtle (*Caretta caretta*) **18**

Figure 1.11. Distributions of loggerhead populations (distinct population segments, DPSs, under ESA) that occur within U.S. territories and its Exclusive Economic Zone (EEZ) **18**

Figure 1.12. Green turtle (*Chelonia mydas*) in St. John, USVI **19**

Figure 1.13. Distributions of green turtle populations (distinct population segments, DPSs, under ESA) that occur within U.S. territories and its Exclusive Economic Zone (EEZ) **19**

Figure 1.14. Leatherback turtle (*Dermochelys coriacea*) in Suriname **20**

Figure 1.15. Distributions of leatherback populations (distinct population segments, DPSs, under ESA) that occur within U.S. territories and its Exclusive Economic Zone (EEZ) **20**

Figure 1.16. Kemp's ridley turtle (*Lepidochelys kempii*) at Rancho Nuevo, Mexico **21**

Figure 1.17. Distributions of the Kemp's ridley population within U.S. territories and its Exclusive Economic Zone (EEZ), which is also the distribution for the species **21**

Figure 1.18. Hawksbill turtle (*Eretmochelys imbricata*) in St. John, USVI **22**

Figure 1.19. Distributions of hawksbill populations that occur within U.S. territories and its Exclusive Economic Zone (EEZ) **22**

Figure 1.20. Hawksbill hatchlings emerge from a nest on Pajaros Beach, Isla de la Mona, in the Mona Channel west of Puerto Rico **23**

Figure 1.21. Olive ridley turtle (*Lepidochelys olivacea*) in Nancite, Costa Rica **23**

Figure 1.22. Distributions of the olive ridley populations that occur within U.S. territories and its Exclusive Economic Zone (EEZ) **23**

Figure 1.23. Olive ridley arribada in Odisha, India **24**

Figure 1.24. Flatback turtle (*Natator depressus*) **24**

Figure 2.1. Cold stunned green sea turtle **29**

Figure 2.2. Jaguar (*Panthera onca*) and green turtle (*Chelonia mydas*) at Tortuguero National Park, Costa Rica **30**

Figure 2.3. A great white shark (*Carcharodon carcharias*) attacking a green turtle (*Chelonia mydas*) off Isla Guadalupe, Mexico **30**

Figure 2.4. Green sea turtle with severe fibropapillomatosis in Hawaii **31**

Figure 2.5. Sea turtles caught in a gillnet off the coast of Brazil **32**

Figure 2.6. A sea turtle escapes from a trawl net through a turtle excluder device (TED) **32**

Figure 2.7. Turtle eggs for sale in a Malaysian market **33**

Figure 2.8. Olive ridley arribada at Ostional, Costa Rica, November 2006 **33**

Figure 2.9. Turtle nesting beach in North Carolina where homeowners placed sandbags to halt erosion, rendering previous nesting sites inaccessible **34**

Figure 2.10. Green turtle with fractured carapace from vessel propeller **35**

Figure 2.11. Olive ridley turtle suspected to have been killed by a hopper dredge (background) in Rio de Janeiro State, Brazil **35**

Figure 2.12. Hawksbill turtle entangled in plastic lines and fishing net **36**

Figure 3.1. Stranded olive ridley sea turtle during 2017 oil spill near Chennai, India **42**

Figure 3.2. Potential routes of exposure to oil and effects in marine and terrestrial habitats **43**

Figure 3.3. Green turtles basking on the bedrock shoreline of Kaloko-Honokohau National Historical Park, Hawaii **44**

Figure 3.4. Oiled Kemp's ridley sea turtle captured in a Gulf of Mexico convergence zone during the 2010 *Deepwater Horizon* spill **44**

Figure 3.5. Direct observations of oil on sea turtles during the *Deepwater Horizon* oil spil **45**
Figure 3.6. Mouth and esophagus of sea turtles during *Deepwater Horizon* response showing obvious ingestion of oil **45**
Figure 3.7. Heavily oiled Kemp's ridley turtle recovered during the *Deepwater Horizon* at-sea response **47**
Figure 4.1. Example of ICS-202 form for Incident Objectives during an oil spill response **54**
Figure 4.2. Venn diagram illustrating response objective tradeoffs and selection of a preferred strategy **55**
Figure 4.3. Schematic for Endangered Species Act Section 7 consultation process, pre-incident and during an emergency **56**
Figure 4.4. Example organizational chart of an Incident Command Structure for an oil spill affecting sea turtles **58**
Figure 4.5. Example of ESI map produced for coastal North Carolina showing known sea turtle distribution and habitat locations **60**
Figure 4.6. Three primary response approaches for open-water environments **62**
Figure 4.7. Comparison of areal coverage for different on-water response methods, a key element of spill response encounter rates **62**
Figure 4.8a. Satellite photo of *Deepwater Horizon* response activities in the Gulf of Mexico on June 15, 2010 **63**
Figure 4.8b. Detail of area highlighted in Figure 4.8a, showing vessel skimming activity **63**
Figure 4.9. Aerial dispersant application from a Basler BT-67 fixed wing aircraft during *Deepwater Horizon* spill, May 2010 **64**
Figure 4.10. *In-situ* burning operations in the Gulf of Mexico during *Deepwater Horizon* spill in 2010 **66**
Figure 4.11. Decision flowchart for evaluating *in-situ* burning as a spill response option **69**
Figure 4.12. Closeup of *Sargassum sp.*, showing the floats (pneumatocysts) that keep the plant at the surface of the water **70**
Figure 4.13. Closeup photo of *Sargassum* and oil along a convergence line in the Gulf of Mexico, 2010 **70**

Figure 4.14. Aerial dispersant application from a Basler BT-67 fixed wing aircraft targeting emulsified oil in a convergence line during the *Deepwater Horizon* spill, May 2010 **70**

Figure 4.15. Primary response approaches for shorelines **71**

Figure 4.16a & b. Sea turtle nest in Bahia Honda State Park, Florida observed during a Shoreline Cleanup Assessment Technique (SCAT) training class **72**

Figure 4.17. Mechanized excavation of a sand beach for SCAT during the *Deepwater Horizon* spill to survey for buried oil **73**

Figure 4.18. Manual removal of residual oil during the *Deepwater Horizon* spill in the Bon Secour National Wildlife Refuge, Alabama**73**

Figure 4.19. A sea turtle nest at risk the 1993 *Bouchard B155* oil spill in Tampa Bay **74**

Figure 4.20. "Operation Deep Clean" excavation activity near Gulf Shores, Alabama, January 8, 2011 **74**

Figure 4.21. Power Screen bulk sieving operation in Gulf Shores, Alabama, January 8, 2011 **74**

Figure 4.22. Vacuuming oil at the edge of a mangrove stand during the 1993 Tampa Bay barge spill **75**

Figure 4.23. Adsorbent "snare" boom, or "pom-poms," deployed on a beach at Fourchon Beach, LA, during the *Deepwater Horizon* spill **75**

Figure 4.24. Dedicated mammal/turtle overflight photo from the *Deepwater Horizon* spill showing loggerhead turtle and fish (likely cobia) in oil slick **77**

Figure 4.25. Sea turtle vessel reconnaissance along a convergence zone in the Gulf of Mexico during the *Deepwater Horizon* oil spill in 2010 **78**

Figure 4.26. Veterinary care being administered at the Audubon Nature Institute, New Orleans, to a Kemp's ridley turtle recovered during the *Deepwater Horizon* spill **79**

Figure 4.27. NOAA TAP model run for the *Deepwater Horizon* spill **80**

Figure 4.28. U.S. Park Service and U.S. Fish and Wildlife Service personnel excavate a sea turtle nest in Bon Secour National Wildlife Refuge, Alabama, during the *Deepwater Horizon* spill **81**

Figure 5.1. Number and estimated volume of reported oil spills worldwide from 1940-2017 **88**

Figure 5.2. Number and estimated volume of reported oil spills shown by latitude from 1957-2017 **88**

Figure 5.3. Total number of oil spills from vessel, non-vessel (pipeline & production facilities), and mystery sources, by year **90**

Figure 5.4. Total volumes of oil spilled from vessel, non-vessel (pipeline & production facilities), and mystery sources, by year; excludes releases due to Hurricanes Katrina & Rita; excludes *Deepwater Horizon* spill **90**

Figure 5.5. Total U.S. oil spills (parsed into oil industry and other sources) into marine and inland waters, 1968-2007 **90**

Figure 5.6. 1970-2016 worldwide oil tanker spill trends **91**

Figure 5.7. Remains of tanker *Witwater* off the coast of Panama in early 1969 **92**

Figure 5.8. *Ixtoc I* well blowout in the Bay of Campeche, Mexico, 1979 **93**

Figure 5.9. Burning oil and gas at the water's surface above the *Ixtoc I* wellhead **93**

Figure 5.10. Heavy residual oiling on Abu Ali Island, Saudi Arabia in 1992 **94**

Figure 5.11. T/V *Alvenus*, grounded south of the Calcasieu River, Louisiana in July 1984 **95**

Figure 5.12. T/V *Mega Borg*, offshore of Galveston, Texas, June 1990 **95**

Figure 5.13. Aerial photo of extremely heavy shoreline oiling along the coast of Saudi Arabia, January 1991 **97**

Figure 5.14. Observer surveying heavy nearshore and beach oiling along the coast of Saudi Arabia in January 1991 **97**

Figure 5.15. Surface oil slick above the sunken barge *Vesta Bella*, April 1991 **97**

Figure 5.16. U.S. Coast Side-Looking Airborne Radar (SLAR) image of oil slick from the sunken *Vesta Bella*, April 1991 **97**

Figure 5.17. Contemporary unimpacted view of Tarague Beach on Andersen Air Force Base, Guam **98**

Figure 5.18. Shoreline oiling encountered on Vieques PR, and chemically fingerprinted to St. Eustatius refinery spill, April 1992 **99**

Figure 5.19. Dead green turtle encountered during shoreline survey for oil related to St. Eustatius refinery spill on Vieques, PR **99**

Figure 5.20. Barge *Ocean 255* ablaze in Tampa Bay, August 1993 **99**

Figure 5.21. Loggerhead hatchling recovered during the Tampa Bay spill response, August 1993 **100**

Figure 5.22. A juvenile green turtle oiled during the 1993 multi-vessel incident in Tampa Bay, Florida **100**

Figure 5.23. Barge *Morris J. Berman* aground off San Juan, Puerto Rico, January 1994 **101**

Figure 5.24. Newspaper coverage of the mystery spill that affected the southeast coast of Florida in August 2000 **102**

Figure 5.25. T/V *Jessica*, grounded on Shiavioni reef at the entrance of Wreck Bay, Isla San Cristóbal, Galápagos, January 2001 **103**

Figure 5.26. Aerial view of Mississippi Block 69 pipeline leak on September 28, 2004 **104**

Figure 5.27a & b. M/T *Vicuña* at Cattalini Terminais Marítimos Ltd terminal, Paranaguá, Brazil, November 16, 2004 **105**

Figure 5.28. M/T *Vicuña* at Cattalini Terminais Marítimos Ltd terminal, Paranaguá, Brazil, Novmber 2004 **105**

Figure 5.29. Members of the Lebanese army observing the placement of protective mesh over a sea turtle nest on El Mansouri and El Koliala beach in southern Lebanon in 2006 **106**

Figure 5.30. M/V *Pacific Adventurer* **106**

Figure 5.31. Hull damage to M/V *Pacific Adventurer*, annotated by Australian Transport Safety Bureau (ATSB) **107**

Figure 5.32. Aerial view of the Montara platform in August 2009 **107**

Figure 5.33. M/V *Shen Neng 1* grounded near the Great Barrier Reef, Australia, April 2010 **108**

Figure 5.34. Mobile offshore drilling unit *Deepwater Horizon* ablaze in the Gulf of Mexico, April 21, 2010 **109**

Figure 5.35. Responders searched convergences areas where oil, pelagic *Sargassum*, and turtles were aggregated during the *Deepwater Horizon* spill. When turtles were observed, responders attempted to rescue them from the surface using dipnets. Oiled turtles were then brought aboard rescue vessels, examined, and cleaned. Turtles were then taken to rehabilitation facilities to receive extended veterinary care until they were ready for release **110**

Figure 5.36. Kirby Barge *27706*, loaded with marine fuel oil and partially submerged in the Houston Ship Channel, March 22, 2014 **111**

Figure 5.37. Manual cleanup of oil from the Ennore oil spill, 2017 **111**

Table of Tables

Table 1.1. Current status under the U.S. Endangered Species Act (ESA) of all sea turtle species that occur within U.S. jurisdiction **9**

Table 1.2. Summary of adult habitat and diets for the six sea turtle species in U.S. waters **10**

Table 1.3. Summary of sea turtle life stages and habitats in U.S. waters **11**

Table 2.1. Relative impacts of anthropogenic threats on sea turtle population in U.S. jurisdiction, based on a global assessment of all sea turtle populations **37**

Table 4.1. Summary of egg translocation and hatchling release effort to prevent Gulf of Mexico hatchlings from being exposed to *Deepwater Horizon* oil and response activities **81**

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NOAA - National Oceanic and Atmospheric Administration. (U.S. Department of Commerce)

NMFS - National Marine Fisheries Service (NOAA)

Introduction

NOAA published the first edition of the Oil and Sea Turtles response guide in 2003. Given the state of knowledge at that time, it was more of an assessment and extrapolation of potential risk than it was documentation of known effects and case studies. Both direct research and empirical spill experience were quite limited, and so we reported what was known and what we found to be concerning from a response perspective based on the biology, life histories, patterns of oil production and transportation, and established response practices.

In this document, we are continuing this discussion and revisiting the same subject areas, with the substantial difference that the *Deepwater Horizon* oil spill occurred in the intervening time. This 2010 incident, the largest marine spill in U.S. history, was notable in numerous ways. Among these was the veterinary and scientific documentation of impacts to living marine resources such as sea turtles and the incorporation of operational considerations for sea turtles into the organized response. For this reason, the *Deepwater Horizon* and the Natural Resource Damage Assessment studies that followed greatly enhanced the knowledge base about how sea turtles and spilled oil interact.

This guidance document is intended as an introduction to what we know and what we learned over the course of the *Deepwater Horizon* experience and other recent incidents. For details of that information, the reader is directed to the referenced scientific literature and in particular, to a much more in-depth assessment produced by NOAA's Assessment and Restoration Division and the National Marine Fisheries Service (2019) under the auspices of the Natural Resource Damage Assessment for the *Deepwater Horizon*.

The experience from the *Deepwater Horizon* confirmed some of the concerns that were articulated in the original 2003 Oil and Sea Turtles guidance document. Smaller turtles, their pelagic habitat, and nesting beaches proved particularly vulnerable to both oil spills and the various response techniques employed to contain and clean up oil. Protection of sea turtles during spills requires a thoughtful, multifaceted approach due to their complex life histories, broad ranges, and diverse habitats. If afforded timely rescue, oiled sea turtles have proven to be relatively resilient and respond well to veterinary care – assistance that inevitably reaches only a fraction of marine animals affected by spills. Despite experience gained from the *Deepwater Horizon* and other recent spills, important knowledge gaps persist, especially related to sublethal and chronic effects of oil. Nevertheless, we continue to produce, transport, and use vast amounts of oil. The risks and effects about which we now know much more continue to loom as one of many threats to the health and prosperity of some of the most intriguing animals in the world's oceans.

Chapter 1. Sea Turtle Biology and Life History

Debra Simecek-Beatty

Key Points

- Sea turtles are reptiles that are found within a wide range of marine habitats, from nearshore areas to open ocean, and lay their eggs on land (beaches). They are long-lived and mature slowly.
- There are seven living species of sea turtles; five are commonly found in continental U.S. waters: the loggerhead, green, leatherback, hawksbill, and Kemp's ridley turtles. A sixth species, the olive ridley turtle, is found in U.S. territorial waters in the Pacific. The seventh species, the flatback, only occurs in the coastal waters of Australia and Indonesia. Sea turtle species are identified by key morphological characteristics, including their shape, color, and the number of scales on their shells and heads.

ESA - Endangered Species Act of 1973, seminal U.S. legislation that provides a framework to conserve and protect endangered and threatened species and their habitats both domestically and abroad

CITES - Convention on International Trade in Endangered Species of Wild Fauna and Flora, a 1975 international agreement to ensure that international trade in animals and plants does not threaten their survival in the wild

- All five species found in coastal U.S. waters are listed as *endangered* or *threatened* under the Endangered Species Act (ESA); all seven species of sea turtles are listed on the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix I list, which prohibits traffic of sea turtle products (e.g., live animals, shell, meat, eggs) in international trade.
- Females return to nest in the same region where they were born, emerging from the sea at night (except for ridleys) to dig an egg chamber and lay eggs. Approximately two months later, hatchlings emerge from their nests and quickly crawl to the sea, also typically at night. Young sea turtles live for several years or more in the open ocean; most species move into nearshore habitats as juveniles. Juvenile and adult sea turtles typically spend most of their time in nearshore areas for foraging and reproduction. Exceptions are leatherback and olive ridley turtles, which are found mainly in deeper waters of continental shelves and in the open ocean.
- Turtles of all species can migrate great distances between feeding and nesting areas, although the lengths of migrations can vary within and across species. While most sea turtle species spend most of the time in tropical to subtropical waters, especially for nesting, leatherbacks range as far north as the waters off Newfoundland and Alaska and as far south as the coasts of Chile and Argentina.
- Several biological traits of sea turtles may make them vulnerable to the harmful effects of oil spills on land and water. For example, sea turtles come ashore to nest where both adult turtles and their offspring may be exposed to oil on beaches. Also, small juvenile sea turtles are found in habitat at the ocean surface formed by converging currents and wind; these areas also aggregate floating oil during spills.

Introduction: What Is a Sea Turtle?

Sea turtles are large (35 to 500 kg) air-breathing reptiles that are highly adapted for life in the marine environment. They are an ancient group of animals that first appear in the fossil record more than 100 million years ago. Sea turtles are characterized by a flattened, streamlined shell and modified wing-like limbs for swimming. Features of their cardiovascular and respiratory systems allow them to dive and control buoyancy. Modified tear glands secrete excess salt. The skull and jaws of each species are adapted to their specific diets. Unlike terrestrial and aquatic turtles, neither the head nor flippers of sea turtles are retractable into their shell.

Sea turtles spend nearly their entire lives at sea. Only females return to land to lay their eggs in nests dug into sand beaches, typically at night. One species, the green turtle, is an exception as individuals come ashore to bask and rest in some locations within the Pacific (e.g., Hawaii, Galapagos, Australia). Every two to four years, female turtles return to nest in the region where they were born, sometimes returning to the same beach. They typically nest several times within a nesting season. After the eggs develop and hatch, following around two months of incubation, hatchling turtles emerge from their nests, usually at night, and head directly to the sea. All sea turtle species require a decade or more to reach adulthood after entering the ocean as hatchlings; this period of maturation may take more than 30 years for some species such as green turtles and loggerheads.

Sea turtles are capable of migrating vast distances, traveling hundreds or even thousands of kilometers between breeding and foraging areas, traversing a wide latitudinal range that spans tropical and temperate waters for some species. They have excellent navigational abilities, orienting by the Earth's magnetic fields and other environmental cues that allow them to predictably return to specific regions for feeding and reproduction.

Sea Turtle Species and Their Conservation Status

Five species of sea turtle are commonly found in U.S. waters: the loggerhead, green, leatherback, hawksbill, and Kemp's ridley turtle. A sixth species, the olive ridley turtle, is found in U.S. territorial waters; and the seventh species, the flatback turtle, occurs only near Australia and Indonesia. Species are identified by various morphological characteristics, including the shape of their head and shell, the number and pattern of scutes and scales, color, and size (Figures 1.1 & 1.2). In addition, multiple species are divided into different populations or subpopulations based on their separate geographic ranges and degree of genetic relation.

Scute - A hard (keratinized) external plate or scale on the shell of a turtle

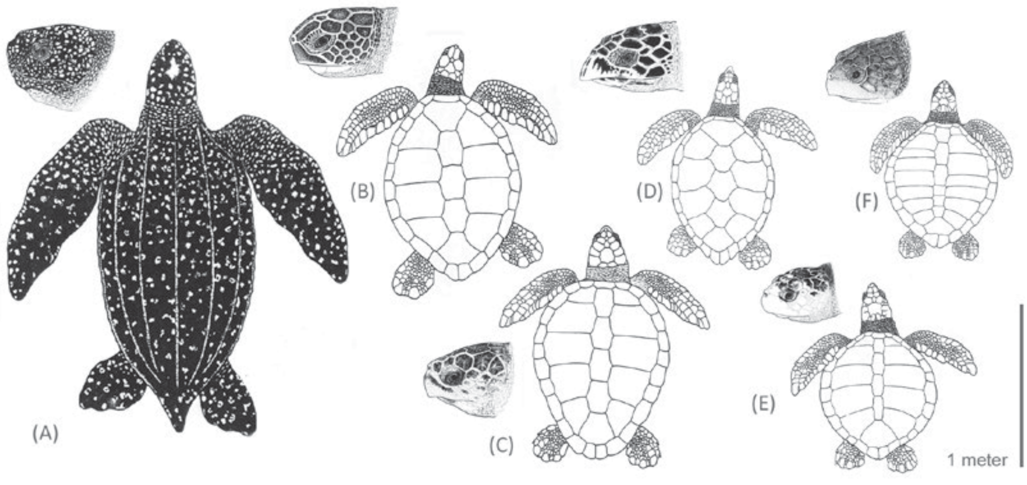
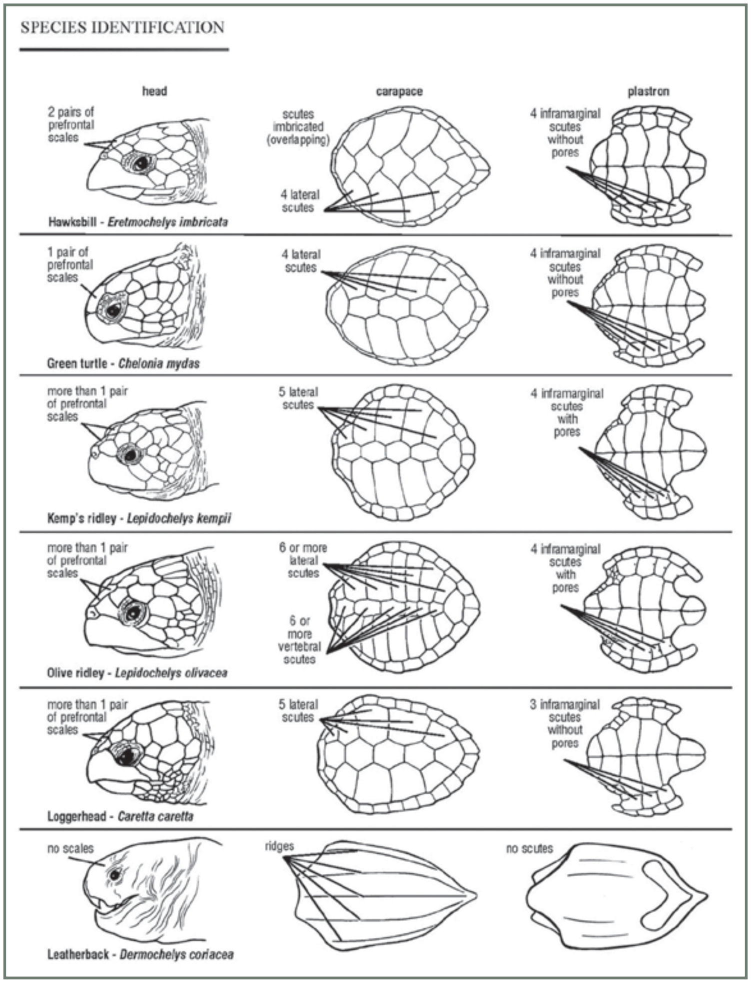


Figure 1.1. Sea turtle species found in U.S. waters (to scale by average adult size). Original illustrations by Thomas McFarland, used with permision.

Figure 1.2. Guide to sea turtles found in United States territorial waters. Prefrontal scales are those located between the eyes. Lateral scutes lie on each side of the vertebral (center) scutes. Drawing courtesy of Dawn Witherington and Jeanette Wyneken.



All sea turtles that occur within U.S. jurisdiction are listed as either *endangered* or *threatened* under the U.S. Endangered Species Act (ESA) (Table 1.1). Endangered status implies that a species is at risk of extinction throughout all or a significant portion of its range. Species likely to become endangered within the foreseeable future are considered *threatened*. Kemp's ridleys, and all populations of hawksbills and leatherbacks are listed as endangered under the ESA. Olive ridleys are listed as threatened, except the Pacific Mexico breeding population, which is listed as endangered. Green turtles are considered threatened wherever they occur in U.S. waters of the Atlantic, Gulf of Mexico, and Caribbean as well as in the East Pacific. Loggerheads in the Gulf of Mexico belong to the Northwest Atlantic population and are listed as threatened; those in the North Pacific are endangered. Within a species, subgroups or populations may be designated as distinct population segments (DPS) under the ESA and may have different status under the Act. *Critical habitat*, which are areas essential to conservation of an ESA-listed species, has been designated under the ESA in the U.S. for green turtles, hawksbills, leatherbacks, and loggerheads (Table 1.1). Table 1.2 presents basic information about habitats and diets of adults of all sea turtle species.

Table 1.1. Current status under the U.S. Endangered Species Act (ESA) of all sea turtle species that occur within U.S. jurisdiction.

Species	Threatened populations	Endangered populations	Critical habitat
Green turtle *(Chelonia mydas)*	Central North Pacific, East Indian-West Pacific, East Pacific, North Atlantic, North Indian, South Atlantic, Southwest Indian, Southwest Pacific	Central South Pacific, Central West Pacific, Mediterranean	50 CFR 226.208 Culebra Island, Puerto Rico – Waters surrounding the island of Culebra from the mean high water line seaward to 3 nautical miles (5.6 km). These waters include Culebra's outlying Keys including Cayo Norte, Cayo Ballena, Cayos Geniquí, Isla Culebrita, Arrecife Culebrita, Cayo de Luis Peña, Las Hermanas, El Mono, Cayo Lobo, Cayo Lobito, Cayo Botijuela, Alcarraza, Los Gemelos, and Piedra Steven.
Hawksbill *(Eretmochelys imbricata)*		All	50 CFR 17.95 Puerto Rico: (1) Isla Mona. All areas of beachfront on the west, south, and east sides of the island from mean high tide inland to a point 150 m from shore. This includes all 7.2 km of beaches on Isla Mona. (2) Culebra Island. The following areas of beachfront on the north shore of the island from mean high tide to a point 150 m from shore: Playa Resaca, Playa Brava, and Playa Larga. (3) Cayo Norte. South beach, from mean high tide inland to a point 150 m from shore. (4) Island Culebrita. All beachfront areas on the southwest facing shore, east facing shore, and northwest facing shore of the island from mean high tide inland to a point 150 m from shore. 50 CFR 226.209 Mona and Monito Islands, Puerto Rico – Waters surrounding the islands of Mona and Monito, from the mean high water line seaward to 3 nautical miles (5.6 km).
Kemp's ridley *(Lepidochelys kempii)*		All	None designated in the United States.
Leatherback *(Dermochelys coriacea)*		All	50 CFR 17.95 U.S. Virgin Islands – A strip of land 0.2 miles wide (from mean high tide inland) at Sandy Point Beach on the western end of the island of St. Croix beginning at the southwest cape to the south and running 1.2 miles northwest and then northeast along the western and northern shoreline, and from the southwest cape 0.7 miles east along the southern shoreline. 50 CFR 226.207 The waters adjacent to Sandy Point, St. Croix, U.S. Virgin Islands, up to and inclusive of the waters from the hundred fathom curve shoreward to the level of mean high tide with boundaries at 17°42'12" North and 64°50'00" West.

Table 1.1 continued.

Species	Threatened populations	Endangered populations	Critical habitat
Loggerhead *(Caretta caretta)*	Northwest Atlantic, South Atlantic, Southeast Indo-Pacific, Southwest Indian	NE Atlantic, Mediterranean, North Indian, North Pacific, South Pacific	50 CFR 226 Specific areas for designation include 38 occupied marine areas within the range of the Northwest Atlantic Ocean DPS. These areas contain one or a combination of habitat types: Nearshore reproductive habitat, winter area, breeding areas, constricted migratory corridors, and/or *Sargassum* habitat (79 FR 39855). The U.S. Fish and Wildlife Service (USFWS) is issuing a final rule for loggerhead critical habitat for terrestrial areas (nesting beaches) in a separate document (79 FR 39755). In total, approximately 1,102 kilometers (685 miles) fall within the boundaries of the critical habitat designation.
Olive ridley *(Lepidochelys olivacea)*	All other populations	Pacific Mexico	None designated in the United States.

Table 1.2. Summary of adult habitat and diets for the six sea turtle species in U.S. waters.*

Species	Habitat	Diet
Loggerhead	Shallow continental shelf, coastal bays	Benthic invertebrates (e.g., mollusks, crustaceans)
Green	Nearshore, coastal bays	Seagrasses, macroalgae, soft-bodied invertebrates
Leatherback	Continental shelf and oceanic areas, water column	Jellyfish, salps, pyrosomes
Kemp's ridley	Coastal bays, shallow continental shelf	Primarily crabs, other benthic invertebrates
Hawksbill	Reefs, coastal areas, lagoons	Primarily sponges, other benthic invertebrates
Olive ridley	Coastal bays, continental shelf, oceanic areas	Salps, invertebrates (e.g., crustaceans, squid, sea urchins)

* Multiple studies also list fin fish among dietary items, which is often attributable to feeding upon anthropogenic or other sources of dead fish (e.g., bait, bycatch, fish kills), which may comprise a significant proportion of the diet for some species and regions.

In addition to sea turtles' ESA listing status, several international conservation treaties and agreements (e.g., Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC), International Union for the Conservation of Nature (IUCN) Red List of Threatened Species reflect their status as species considered to be in danger of extinction if current threats are not reduced. Of particular importance, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) includes all seven sea turtle species on its Appendix I list, which prohibits their traffic in international trade.

In the U.S., the NOAA/National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) share federal jurisdiction for the conservation and recovery of sea turtles. The roles of the two agencies are defined in a joint Memorandum of Understanding (MOU), originally entered into in 1977, and updated in 2015 (Appendix A). USFWS has jurisdiction in the terrestrial environment and NMFS has jurisdiction in the marine environment, unless otherwise specified in the MOU. In addition, state agencies coordinate with the federal agencies to fulfill management responsibilities within individual states.

Sea Turtle Life History

The sea turtle life cycle includes multiple stages that collectively last decades, and may occur over several distinct habitat types (Figure 1.3). The following review applies some generalizations in order to provide readers with a complete sense of life history, especially as it relates to later discussions of vulnerability to anthropogenic threats. In reality, these life cycles vary significantly based on geographic location and both within and among species, and even among individuals within populations.

Beaches and waters of the U.S. represent habitat for six of the seven sea turtle species. Usage and occurrence vary by life stage and species, but are generally summarized in Table 1.3.

Table 1.3. Summary of sea turtle life stages and habitats in U.S. waters (Source: NOAA, 2019).

Life stage	Habitat in the U.S.	Behavioral characteristics	Seasonality
Nesting females, eggs, hatchlings	Sandy beaches mainly in the Southeast U.S., Hawaii, and overseas territories	Females nest on beaches; embryos develop while buried in sand; hatchlings emerge and enter the ocean	Southeast U.S. and Hawaii: mating occurs between March-June, nesting occurs between March-October, hatchlings emerge between May-November
Post-hatchlings and small juveniles	Open ocean; including surface habitats throughout Atlantic Ocean (including the Gulf of Mexico) and Pacific Ocean	Spend more than 80 percent of their time at or near the sea surface; limited diving ability; tend to associate with floating *Sargassum* in the Atlantic and Gulf of Mexico; drift and swim to remain in surface currents	Year-round

Table 1.3 continued.

Life stage	Habitat in the U.S.	Behavioral characteristics	Seasonality
Large juveniles and adults	Continental and insular shelves; nearshore and inshore habitats; and beaches (basking, Hawaii only)	Use the entire water column, from surface to bottom; active swimmers; dive frequently and typically deeper than 20 meters; spend on average 10 percent of time at the surface; exhibit seasonal and non-seasonal migrations; individuals consistently use the same breeding and foraging areas; in Hawaii, green turtles bask on beaches	Turtles are present in many areas year-round, but in higher densities near nesting beaches, foraging areas, and along reproductive corridors prior to and during the nesting season (summer months), and lower densities at higher latitudes during winter months; female turtles remain in the vicinity of the nesting beach until they have nested multiple times in a season

Figure 1.3 depicts egg laying on nesting beaches as the beginning of the sea turtle life cycle. Sea turtles return to the same region, sometimes even the same beach, from which they hatched – their natal beach – to lay their eggs. Most sea turtles nest at night; although both species of ridley are exceptions and frequently nest during the day. Females crawl onto the beach to nest above the high-tide line. The general requirements for a nesting beach are that it is high enough to not be inundated by seawater at high tide and has sand that permits gas exchange, but is moist and fine enough that it won't collapse as the turtle excavates a chamber for the eggs. Sea turtles lay between 60-200 parchment-shelled eggs (number varies by species) in each clutch. Unique features of tracks left by female turtles can be used to identify different species.

Figure 1.3 shows 1) The cycle begins with egg laying. 2) Hatchings leave nesting beaches and swim away from the coast to reach open ocean (i.e., typically >200 meters

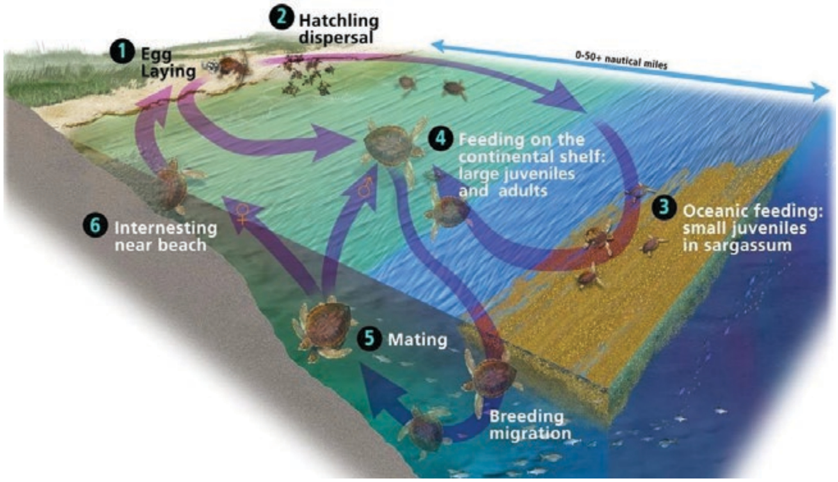


Figure 1.3. Generalized sea turtle lifestyle. Illustration by Kate Sweeney.

depth). 3) They remain for several years as oceanic juveniles associated with surface habitats (e.g., Sargassum seaweed in the Atlantic and Gulf of Mexico). 4) After growing to larger body sizes, they move onto the continental shelf and closer to shore as neritic juveniles. 5) Upon reaching adulthood, they migrate for breeding, sometimes across open ocean, to the region where they were born. 6) Adult male turtles return to foraging areas after mating, while adult females remain during mating seasons that can last 1-2 months. Hatchlings emerge from eggs laid on sand beaches, which initiates a new cycle.

Sargassum - a genus (*Sargassum*) of brown algae that have a branching thallus with lateral outgrowths differentiated as leafy segments, air bladders, or spore-bearing structures

Females generally deposit from 1 to 10 egg clutches per season, laying at regularly spaced intervals of 10 to 20 days. After laying each clutch, they return to waters near the nesting beach until the next clutch develops, nest again, and so on until they have finished laying eggs for a given year. Female turtles of most species nest only every two to four years.

The nesting characteristics of Kemp's and olive ridley turtles are different from other sea turtles in multiple ways. Both species nest during the day and individual females frequently nest every year (Figure 1.4). Also, both ridley species nest individually or in synchronized, mass nesting events called arribadas, Spanish for "arrivals" (Figures 1.5 & 1.20). Arribadas typically occur at three- to four-week intervals and can include hundreds or thousands of females.

Figure 1.4. Kemp's ridley turtle laying eggs at South Padre Island, Texas. Photo courtesy of Adrienne McCracken, Loggerhead Marinelife Center.

After an incubation period of about two months, depending on temperature, hatchlings dig their way up to the surface more or less simultaneously. Thus, most hatchlings emerge from their nest on a single night, with only a few stragglers following on subsequent nights. High surface-sand temperatures can inhibit hatchling movement, so most emergences occur at night, after the sand has cooled, although daytime emergences on cloudy days or after a rain are not uncommon. When they first emerge from their eggs, hatchlings weigh only around 25-45 g. (less than 2 oz.), depending on species.

Arribada - Spanish word meaning "arrival by sea" and refers to the mass nesting behavior exhibited by Kemp's ridley and olive ridley sea turtles

Upon emerging from the nest, the hatchlings scramble across the beach to the ocean, orienting away from the darkness of the duneline and moving toward the shine of the surf (Figure 1.6). Once in the water, hatchlings then orient into the waves, engaging in continuous, vigorous swimming that transports them to offshore waters within the first 24 to 48 hours.

After reaching offshore (i.e., oceanic) waters, small juvenile sea turtles spend their early years feeding near the surface in floating *Sargassum* (Atlantic and Gulf of Mexico) and around upwellings and other features where prey are found. These young turtles are called oceanic or *surface-pelagic juveniles* because they inhabit the upper water column in areas far from shore. At this stage, they are still relatively small, growing to around 25 cm (10 inches) within the first 1 to 2 years of life. This oceanic period lasts from years to decades, depending on species. Oceanic juveniles tend to move within open ocean

Figure 1.5. Aerial view of arribada of Kemp's ridley turtles at Rancho Nuevo, Mexico. Note the numerous overlapping tracks created by females as they crawled to nest above the high tide line. PPhoto courtesy of CONANP / Gladys Porter Zoo.

gyres, which are large offshore systems of circulating ocean currents (Figure 1.7). For example, loggerhead turtles born on the U.S. Atlantic coast circle past Europe and the Mediterranean Sea before returning as juveniles to the U.S. eastern seaboard.

Older, larger juveniles of most species then enter continental and insular shelf areas (neritic zone), including bays and estuaries, where they spend more years feeding and growing to maturity (Figure 1.3). Sea turtles may exhibit strong fidelity to specific foraging areas and migrate to different foraging areas as they get larger.

Estimates of age at sexual maturity vary not only among species, but also among different populations of the same species. Overall, age at maturity ranges from around 12 years for Kemp's ridleys to between 25 to 50 years in green turtles and loggerheads.

Mature, breeding females and males migrate from foraging grounds to breeding areas adjacent to nesting beaches. Foraging and breeding areas may be relatively close together – some hawksbills breed and feed in Puerto Rico, for example – or they may be hundreds to thousands of miles apart. Sea turtles usually mate when mature males and females congregate in waters off nesting beaches or during migration right before nesting begins. The life cycle begins anew as females crawl onto beaches to dig nests and lay their eggs.

*Figure 1.6. Loggerhead turtle (*Caretta caretta*) hatchlings emerging from a nest in the Florida Keys, July 2014. Webcam photo capture from fla-keys.com/ turtlecam.*

Leatherbacks are an exception to this generalized sea turtle life cycle. Upon hatching, leatherbacks do not move passively with the open ocean gyres; instead they become active foragers in convergence zones and upwellings within the water column. Leatherbacks of all life stages spend more time in deeper water areas than other species, and frequent continental shelf as well as distant offshore waters. Adults, in particular, undertake epic migrations across entire ocean basins, and actively forage in the cold waters of high latitudes. Leatherbacks in the Northwest Atlantic can migrate more than 10,000 km between breeding areas in the Caribbean to foraging areas in New England and Nova Scotia. Pacific olive ridleys also are more oceanic than the other species.

*Figure 1.7. A juvenile green turtle (*Chelonia midas*) in* Sargassum. *Photo: Blair Witherington, Florida Fish and Wildlife Conservation Commission.*

General Behavioral and Physiological Traits of Sea Turtles

As truly marine reptiles, sea turtles exhibit a number of specialized adaptations. Some aspects of their biology put them at risk of exposure to oil or oil cleanup activities during spills. For example, all sea turtles must spend time at the surface to breathe, rest, bask, and feed. These fundamental behaviors place turtles at continuous and repeated risk of exposure anywhere that oil or cleanup activities are present on the ocean's surface. Likewise, the requirement that turtles come ashore to lay their eggs puts nesting turtles and their eggs and hatchlings at risk of exposure to oil and spill response activities on beaches. In the following paragraphs, we review biological traits that are most relevant to oil spills and the associated risks. Specific harmful effects of spills and related activities are reviewed in greater detail in later chapters.

Development

As demonstrated in many different types of animals, early developmental stages are relatively sensitive to the constituent chemicals of petroleum. Development of sea turtle eggs is a lengthy process that begins a year or more prior to the time eggs are laid on nesting beaches. Females form yolk (which nourishes embryos during development), over the course of many months as they feed and accumulate energetic resources necessary for reproduction. By the time they arrive at nesting beaches, they have already formed the yolk necessary for all clutches of eggs that will be laid that year. Eggs are formed within the female reproductive tract, including formation of the outer shell. The developing embryo is microscopic at this stage and consists of a tiny collection of cells. Once the eggs are laid into the nest, a series of events occurs that causes the embryo and surrounding membranes to adhere to the top of the egg. After about 10 hours, any movement of the egg, e.g., by accidental excavation or other disturbance, may kill the embryo. During the course of incubation, eggs take in air and water from the surrounding sand. Chemicals within the sand likewise may be absorbed by the embryo and alter the gas and fluid exchange properties of shell. Also, changes in the color or make-up of the sand can affect the temperature or physical properties of the nest and significantly alter the incubation environment.

Navigation and sensitivity to disturbance

During nesting, female sea turtles are relatively sensitive to any disturbance on nesting beaches. They will avoid areas of human presence, noise, lights, and other activity, and will abort their attempts at nesting or even forego nesting entirely if disturbance is widespread and continuous. Failed attempts to nest can be recognized by tracks left on beaches that show only crawls, not nesting activities (Figure 1.8). In addition, both hatchlings and female sea turtles have poor vision out of the water and rely on the faint light of the horizon and darkness of land to find the ocean. Sea turtles came into existence long before artificial lights and modifications of beaches were created by man. Lighting on poles, buildings, vehicles, and other sources disorients them and prevents them from finding their way to the ocean, which can result in death. Even tire ruts and other manmade depressions in the sand can create insurmountable physical barriers for hatchlings.

Figure 1.8. Tracks showing a non-nesting haulout in the Archie Carr National Wildlife Refuge, Florida, June 2009. Photo courtesy of David McRee.

Small turtles and habitat use

Although sea turtles reach relatively large sizes as adults, they begin life as tiny hatchlings and small juveniles. These young turtles live near the sea surface, where they feed, swim, and drift. Due to oceanographic forces and wind, floating oil tends to accumulate within the same types of areas where these turtles are found. Small turtles have limited ability to extricate themselves from oil, especially its more tenacious forms. In addition, response actions such as booming, skimming, controlled burning, and application of dispersants tend to focus on the same areas and habitats where these small turtles are found. These oil and oil spill response considerations will be discussed in greater detail in Chapters 3 and 4.

Diving and metabolism

Sea turtles are among the most active air-breathing marine vertebrates, spending as little as 3 to 6 percent of their time at the surface. While most sea turtle species routinely dive no deeper than 10 to 50 m, the deepest recorded dives for leatherbacks are over 1,000 m. Routine dives may last anywhere from 15 to 20 minutes to nearly an hour or more, depending on environmental conditions and other factors. The primary adaptations that permit extended, repeated dives are efficient transport of oxygen and a tolerance for low-oxygen conditions, or hypoxia. During routine dives, sea turtles will surface to breathe well before they run out of oxygen. Upon surfacing, a sea turtle exhales forcefully and rapidly, requiring only a few breaths, each less than a few seconds, to empty and refill its lungs. Such high air flow rates are possible because turtles have large, reinforced airways, and their lungs are extensively subdivided, which increases gas exchange between the lungs and the bloodstream. While diving, the heart rate slows and blood flow to organs and muscles changes to manage use of oxygen and maintain function. The necessity of breathing air and the unique aspects of their respiratory physiology make sea turtles vulnerable to threats at the sea surface, including floating oil, and potentially expose them to chemicals in the air.

In addition, sea turtles that are forcibly held underwater or undergo intense physical activity as a consequence of capture or entrapment in manmade materials (e.g., thick oil, oil boom) will rapidly consume their oxygen stores and convert glucose to lactic acid for energy, a process called *anaerobic metabolism*. Lactic acid levels can rise rapidly, even to lethal levels. Although there are physiological mechanisms that compensate for these effects, recovery can take many hours or even days following stressful events that are especially prolonged or very intense. During recovery, turtles are vulnerable to predators and other threats.

Anaerobic metabolism – **metabolism occurring in the absence of oxygen**

Feeding behavior

The diets of sea turtles vary by species and life stage, as discussed in the next section, and range from bottom-dwelling animals and vegetation to invertebrates and macroalgae (seaweed) found at the sea surface. Although sea turtles appear to use multiple senses to find prey, they are prone to ingestion of foreign material, including forms of petroleum such as tar balls. These occurrences may be due to indiscriminate or investigative feeding behavior or because foreign material is mistaken for natural food items. In addition, juvenile and adult life stages of most species forage on the sea floor where they may incidentally ingest sediments and any chemicals or other substances within those sediments. Two species, loggerheads and Kemp's ridleys, are known to actually dig into the sea floor in pursuit of invertebrate prey (Table 1.2).

Species Descriptions

The following sections present basic biology and life history information for the six sea turtle species that occur in U.S. waters. The seventh sea turtle species, the flatback (*Natator depressus*), is discussed only briefly in this guide because it occurs exclusively in and adjacent to Australia's continental shelf.

Loggerhead Turtle, *Caretta caretta*

The loggerhead turtle (Figures 1.9 & 1.10) is one of the most common turtle species found in the southeast U.S. In fact, one of the largest nesting assemblages of loggerheads in the world occurs in the eastern U.S., which hosts more than 100,000 nests in some years. There are nine recognized distinct population segments (DPSs) for loggerhead sea turtles under the ESA. The two DPSs that occur in U.S. waters are the Northwest Atlantic DPS and the North Pacific DPS (Figure 1.11). These DPSs are listed as Threatened (Northwest Atlantic) and Endangered (North Pacific) under the ESA.

*Figure 1.9. Loggerhead turtle (*Caretta caretta*). Photo courtesy of ALan Rees / ARCHELON.*

Carapace - top (dorsal) side of a sea turtle shell

Plastron - bottom (ventral) side of a sea turtle shell

Identification

Adults and subadults have a reddish-brown carapace and a dull brown to yellowish bottom shell, called the plastron. Juveniles are also reddish brown, while hatchlings have a yellowish margin on the carapace and flippers. Loggerhead turtles have more than one pair of prefrontal scales between the eyes and five lateral scutes on the carapace (Figure 1.2). Hatchlings and juveniles have sharp keels on the vertebral scutes (see Figure 1.8) that recede with age. In the Atlantic, adult loggerheads have shells that

*Figure 1.10. Juvenile loggerhead turtle (*Caretta caretta*). Note sharp keel on carapace. Photo courtesy of Brian Gratwicke, Smithsonian National Zoological Park.*

measure around 90 to 100 cm long and weigh over 100 kg. Loggerheads in other areas of the world are generally somewhat smaller.

Range

Loggerheads are globally distributed in the tropics and subtropics, although they vary in abundance, trends, and other traits among regions. In the Western Hemisphere, loggerheads may range as far north as Newfoundland (rare) to as far south as Argentina. Along the Pacific coast, loggerheads range from the Gulf of Alaska southward, but are most frequently seen off the western Baja Peninsula.

Nesting occurs in the northern and southern temperate zones and subtropics (they generally avoid nesting on tropical beaches). Ninety percent of nesting in the U.S. occurs along the central and southeast Florida coast, though regular nesting also occurs in Georgia, the Carolinas, and in the Gulf of Mexico along the Florida Panhandle and in Alabama. Other large nesting assemblages for loggerheads are in Cape Verde and Oman. Loggerheads nest in fewer numbers in other regions, including the Caribbean, other areas of the Atlantic (e.g., Brazil), the eastern Mediterranean, the Indian Ocean, as well as the North Pacific (Japan) and South Pacific (Australia and New Caledonia) regions.

Figure 1.11. Distributions of loggerhead populations (distinct population segments, DPSs, under ESA) that occur within U.S. territories and its Exclusive Economic Zone (EEZ). Note that these represent the core distributions of these populations and not their entire geographic ranges. Source: Wallace et al. (2010).

Habitat

After hatching, baby loggerheads swim directly offshore and eventually associate with pelagic drift lines of convergence zones and other oceanic features. In the Atlantic and Gulf of Mexico, young turtles associate with rafts of floating *Sargassum*, which provide shelter and prey. Loggerheads that hatch from beaches in the southeastern U.S. may circumnavigate the entire northern Atlantic gyre during this oceanic phase of their life before moving to nearshore (neritic) habitats, when they have grown to around 40 to 50 cm.

Adult and subadult loggerhead turtles are found primarily in subtropical (occasionally tropical) waters along the continental shelves and estuaries of the Atlantic, Pacific, and Indian Oceans. They are a nearshore species, but may be found in a variety of habitat types from turbid, muddy-bottomed bays and bayous to sandy bottom habitats, reefs, and shoals.

Diet

Hatchlings and oceanic juveniles hunt near the sea surface where the prey on coelenterates, crustaceans, and other invertebrates. Neritic juveniles and adults feed primarily on mollusks, crustaceans, and other invertebrates found on the seafloor.

Green Turtle, *Chelonia mydas*

*Figure 1.12. Green turtle (*Chelonia mydas*) in St. John, USVI. Photo courtesy of Caroline S. Rogers, U.S. Geological Survey.*

The green turtle (Figure 1.12) is one of the largest sea turtle species, second only to the leatherback. It is also the second most common nesting turtle in the U.S.; however, nesting numbers may soon surpass those of loggerheads given recent increases in the Atlantic populations due to conservation efforts. NMFS and USFWS have defined 11 green turtle DPSs under the ESA to reflect the geographic variation in green turtle populations worldwide (Figure 1.13). Three DPSs occur within U.S. waters, all of which are listed as Threatened under ESA, including the North Atlantic DPS, the East Pacific DPS, and the Central North Pacific DPS.

Identification.

The color and pattern, particularly that of the shell, varies considerably among green turtles. Their carapace can be black to gray to green or brown, often with streaks or spots, and their plastron is yellowish-white. Hatchlings have a dark brown to black carapace and white plastron, with a white margin along the carapace and rear edges. Green turtles have one pair of prefrontal scales, four lateral scutes, a small rounded head, and a single visible claw on each flipper. The beak of green turtles is serrated, a unique characteristic among sea turtles that reflects their largely vegetarian diet. Worldwide, green turtles also vary in size and weight among different populations. In the North Atlantic, adult green turtles have an average shell length of around 100 cm and can weigh over 200 kg.

Range

Adult green turtles are primarily found in tropical and subtropical waters worldwide; juveniles also range into temperate regions. Major global nesting areas for the species are located in Costa Rica, Australia, Ascension Island, and Surinam.

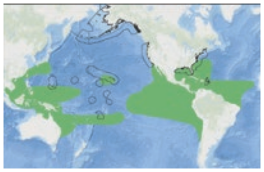


Figure 1.13. Distributions of green turtle populations (distinct population segments, DPSs, under ESA) that occur within U.S. territories and its Exclusive Economic Zone (EEZ). Note that these represent the core distributions of these populations and not their entire geographic ranges. Source: Wallace et al. (2010).

In the North Atlantic, green turtles range from Texas to the U.S. Virgin Islands and Puerto Rico, and north to Massachusetts. Nesting in this region primarily occurs in Florida, the U.S. Virgin Islands, and the Yucatan Peninsula of Mexico. Hawaii hosts an endemic green turtle population that nests in the Northwest Hawaiian Islands but ranges throughout the Hawaiian archipelago. Green turtles of the East Pacific range into waters of California, but are most abundant between Baja California Sur, Mexico, and Peru. This population nests primarily in Mexico, Costa Rica, and the Galapagos.

Habitat

Like most other sea turtle species, green turtles generally use three distinct habitats during their life cycle: nesting beaches, oceanic waters (hatchlings and small juveniles), and neritic areas (adults and large juveniles). Juveniles move from offshore areas into relatively shallow, nearshore waters when they reach 25 to 30 cm straight carapace length (SCL) in the Atlantic and at 35 to 40 cm in the Pacific. Foraging areas consist primarily of seagrass and algae beds, though they are also found over coral and worm reefs, and rocky bottoms. Juveniles also may frequent manmade structures such as jetties and armored inlets. In the U.S. and Territories, important green turtle foraging areas are found in Florida, Texas, California (southern), and throughout the Caribbean and Pacific Islands. Green turtles prefer nesting on high-wave energy beaches, often on islands.

Diet

Small oceanic juvenile green turtles are omnivorous. Adults and large juveniles feed primarily on seagrasses and algae in the North Atlantic and North Pacific.

*Figure 1.14. Leatherback turtle (*Dermochelys coriacea*) in Suriname. Photo courtesy of Linda Reinhold.*

Leatherback turtle, *Dermochelys coriacea*

The leatherback turtle (Figure 1.14), the largest and widest ranging sea turtle, is easily identified by its lack of scutes (hence the name) and distinct shape. Leatherbacks spend more time in deep oceanic waters at all life stages than do other sea turtle species. Leatherbacks are listed as Endangered under the ESA.

Identification

The shell of this enormous sea turtle has seven ridges running from front to rear along its back instead of the usual scutes and is covered by a thin layer of black skin, often with white spots. Leatherbacks have no scales on their heads and no claws on their flippers. Adults range in size from 150 to 170 cm SCL, and can exceed 500 kg. Hatchlings also have carapace ridges and lack scutes; they are two to three times larger than other sea turtle hatchlings.

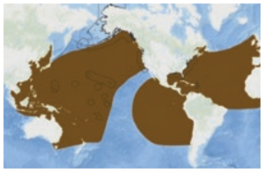


Figure 1.15. Distributions of leatherback populations (distinct population segments, DPSs, under ESA) that occur within U.S. territories and its Exclusive Economic Zone (EEZ). Note that these represent the core distributions of these populations and not their entire geographic ranges. Source: Wallace et al. (2010).

Range

Leatherbacks are among the most widely distributed vertebrates in the world, ranging from foraging areas in sub-polar latitudes to breeding areas in the tropics (Figure 1.15). Adult leatherbacks may range as far north as the coastal waters off Newfoundland or the Gulf of Alaska.

Leatherbacks nest in the tropical zone. In the Northwest Atlantic, they nest throughout the Wider Caribbean Region (e.g., Costa Rica, Surinam, French Guiana, Guyana, Trinidad), and within the U.S. along the Florida coast, the U.S. Virgin Islands (St. Croix in particular), and Puerto Rico (mainland and Culebra Island). In the West Pacific, leatherbacks primarily nest in Indonesia. Those in the East Pacific nest in Mexico and Costa Rica. Leatherbacks that forage off the U.S. West Coast nest in Indonesia and Papua New Guinea.

Habitat

Leatherbacks mostly inhabit open ocean where they feed within the water column, but will come close to shore in pursuit of their prey. They forage at high latitudes in cold water (10-15˚C) when their jellyfish prey are seasonally abundant, as well within more temperate or subtropical waters. Their nesting areas in the tropics tend to be open, high-energy beaches.

Diet

Leatherbacks primarily eat jellyfish, colonial tunicates (pyrosomes), and other gelatinous prey species, as well as the smaller symbiotic animals that live within these organisms.

Kemp's Ridley Turtle, *Lepidochelys kempii*

The Kemp's ridley (Figure 1.16), along with the olive ridley, is the smallest of all sea turtles. It has the most restricted range of all U.S. sea turtle species. Kemp's ridleys are listed as Endangered under the ESA.

*Figure 1.16. Kemp's ridley turtle (*Lepidochelys kempii*) at Rancho Nuevo, Mexico. Photo courtesy of Alejandro Fallabrino.*

Identification

Adult Kemp's ridley sea turtles have light gray to olive or gray-green carapaces and a creamy white or yellowish plastron. Hatchlings are gray-black on both carapace and plastron. Like loggerheads, juvenile Kemp's ridleys have a prominent keeled ridge in the middle of their shell that flattens as they grow. Kemp's ridleys have more than one pair of prefrontal scales and five lateral scutes. Adults usually weigh less than 45 kg and have an average shell length around 65 cm. Their shell is more round that other sea turtles; it is almost as wide as it is long.

Range.

The Kemp's ridley occurs only in the Gulf of Mexico and the northwestern Atlantic Ocean (Figure 1.17). While adults remain almost exclusively in the Gulf of Mexico, the northeastern coast of the U.S. appears to be an important habitat for juveniles, which are often found in waters off New York and New England. The primary nesting area of the Kemp's ridley is in the western Gulf of Mexico near Rancho Nuevo, in Mexico's Tamaulipas state, where turtles may synchronously nest in large numbers (*arribadas*). Fewer nests occur in Texas and other states within the southeastern U.S.

Figure 1.17. Distributions of the Kemp's ridley population within U.S. territories and its Exclusive Economic Zone (EEZ), which is also the distribution for the species. Note that this represents the core distribution of this species and not its entire geographic range. Source: Wallace et al. (2010).

Habitat

Similar to most other species, juvenile Kemp's ridleys remain offshore during early years of life, living near the surface, often associating with floating *Sargassum*, and feeding on invertebrates and other prey. Neritic juveniles and adults frequent habitat with sandy or muddy bottoms, including bays, coastal lagoons, and river mouths.

Diet

Juvenile and adult Kemp's ridleys feed primarily on various types of crabs. They also consume a variety of other invertebrates, such as tunicates and marine snails, and will opportunistically forage on carrion, such as discarded fisheries bycatch (as will other sea turtles).

Figure 1.18. Hawksbill turtle (Eretmochelys imbricata) in St. John, USVI. Photo courtesy of Caroline S. Rogers, U.S. Geological Survey.

Hawksbill Turtle, *Eretmochelys imbricata*

The hawksbill turtle (Figure 1.18) is the most tropical sea turtle, and it is one of the most heavily hunted, both as juveniles and adults, to obtain "tortoiseshell." Hawksbills are listed as Endangered under the ESA.

Identification

The hawksbill turtle has thick carapace scutes, with streaks of brown and black on an amber background. The rear edge of the carapace is deeply serrated. Hawksbills have two pairs of prefrontal scales and four overlapping lateral scutes; a small, narrow head that tapers to a distinct hooked beak; and two claws on each flipper. Hatchlings are mostly brown. Adult hawksbills vary in size, can weigh up to around 85 kg, and have a shell length of 50 to just over 100 cm.

Figure 1.19. Distributions of hawksbill populations that occur within U.S. territories and its Exclusive Economic Zone (EEZ). Note that these represent the core distributions of these populations and not their entire geographic ranges. Source: Wallace et al. (2010).

Range

Hawksbills are found throughout the tropical oceans. The largest populations occur throughout the Wider Caribbean from Brazil to South Florida, across the insular Pacific, in Malaysia and Australia, and along the Eastern Pacific coast of the Americas (Figure 1.19). In the Wider Caribbean region, significant concentrations of hawksbill sea turtle nesting (> 100 females/year) occur in the Yucatan Peninsula of Mexico, Cuba, the Bahamas, the U.S. Virgin Islands, Puerto Rico, French West Indies, Barbados, and Trinidad and Tobago. In the Pacific, there is a small population of hawksbills in Hawaii. In U.S. waters, hawksbills are found in the U.S. Virgin Islands (nesting beaches are in Buck Island National Monument, St. Croix), Puerto Rico (nesting beaches are on Mona Island, Figure 1.20), South Florida, and in Hawaii.

Habitat

In the Atlantic, hawksbills have a life cycle similar to that described for other species. Hatchlings swim offshore and associate with *Sargassum spp.* rafts and other surface habitat as juveniles. They move into shallow reefs when they reach 15 to 25 cm

SCL and then into deeper waters as their size and diving capabilities increase. Hawksbills forage near rock or reef habitats in clear, shallow tropical waters. They are most common near a variety of reef types, from vertical underwater cliffs to gorgonian (soft coral) flats, and also are found over seagrass or algae meadows. Adults are not usually found in waters less than 20 m deep, while juveniles rarely leave shallow coral reefs. In the Eastern Pacific, hawksbills of all life stages tend to use mangrove estuaries, likely due to the lack of coral reef habitats in that region.

Figure 1.20. Hawksbill hatchlings emerge from a nest on Pajaros Beach, Isla de la Mona, in the Mona Channel west of Puerto Rico. Photo courtesy of Michelle Schärer, Department of Marine Sciences, University of Puerto Rico-RUM.

Diet

Hawksbill turtles feed primarily on sponges and may target specific species. They also forage on corals, tunicates, algae, and mangrove seeds.

Olive Ridley Turtle, *Lepidochelys olivacea*

The olive ridley (Figures 1.21), while probably the most abundant sea turtle worldwide, is less frequently encountered in U.S. waters relative to other species. Olive ridleys in the U.S. Pacific waters are listed as Endangered under ESA.

*Figure 1.21. Olive ridley turtle (*Lepidochelys olivacea*) in Nancite, Costa Rica. Photo: © Karla G. Barrientos-Muñoz / Fundacion Tortugas del Mar.*

Identification

The olive ridley, like its close relative, the Kemp's ridley, is a small turtle (generally < 70 cm SCL). The adult carapace is dark gray and nearly round; hatchlings are gray-brown. Olive ridleys have two claws on each flipper, more than one pair of prefrontal scales, and six or more lateral scutes. Juveniles have a prominent keeled ridge in the middle of their shell similar to the Kemp's ridley and loggerhead.

Range.

The olive ridley is found in Indian, Pacific, and South Atlantic waters, but may occasionally be found in the tropical North Atlantic. Along the East Pacific coast, the olive ridley ranges from the Gulf of Alaska to Central America, but is most common in the southern portion of this range, commonly appearing in offshore areas off California (Figure 1.22). Enormous nesting aggregations (arribadas) occur at several sites in the East Pacific (in Mexico, Nicaragua, Costa Rica [Figure 1.23]), and in India. Smaller nesting sites occur along tropical mainland shores worldwide.

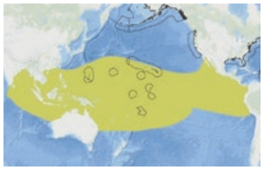


Figure 1.22. Distributions of the olive ridley populations that occur within U.S. territories and its Exclusive Economic Zone (EEZ). Note that this represent the core distribution of this population and not the entire geographic range. Source: Wallace et al. (2010).

Habitat

Olive ridleys are associated with relatively deep, soft-bottomed habitats inhabited by crabs and other crustaceans. They are also common in pelagic habitats, especially

Figure 1.23. Olive ridley arribada in Odisha, India. Photo: Pratap Padh/Shutterstock.

in the East Pacific, and thus are considered to be more oceanic than most other species.

Diet

The diet of olive ridleys can be carnivorous or omnivorous and includes crabs, mollusks, gastropods, fish eggs, jellyfish, and algae.

Flatback Turtle, *Natator depressus*

*Figure 1.24. Flatback turtle (*Natator depressus*). Photo ©Doug Perrine, used with permission.*

The flatback turtle (Figure 1.24) is the only sea turtle species that does not occur in U.S. waters; it is found along the northern coast of Australia and southern New Guinea. The adult carapace is a dull olive-gray edged with pale brownish-yellow, and the plastron is creamy white. The flatback inhabits inshore turbid waters in coastal areas along the main coral reefs and continental islands, where it feeds on a varied diet that includes algae, squid, invertebrates, and mollusks.

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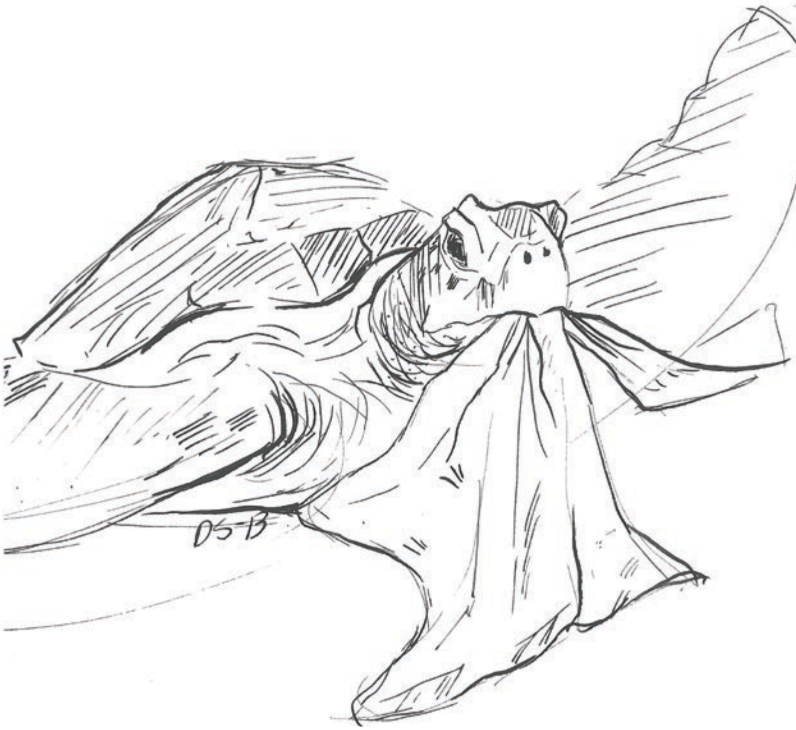
Chapter 2. Natural and Human Threats to Sea Turtles



Debra Simecek-Beatty

Key Points

- A variety of natural and human-caused (anthropogenic) factors affect the health and survival of all life stages of sea turtles.
- Natural mortality factors include the destruction of eggs by inundation or erosion, predation, extreme temperatures, and some forms of disease. Anthropogenic influences can also play a role in some seemingly natural phenomena, such as effects of human-induced climate change on sea turtle habitat.
- Important anthropogenic threats include incidental capture in fisheries, hunting of sea turtles and their eggs for food and products, destruction or alteration of nesting beaches, accidental killing of turtles or degradation of habitat by various human activities, and multiple forms of pollution.

- Anthropogenic threats that affect larger, reproductively important individuals and/or cause sustained, large-scale losses have the biggest impacts on sea turtle populations, which are inherently slow to recover.

Introduction

Many human-caused or anthropogenic threats to sea turtles are straightforward and well-recognized (e.g., drowning in fishing gear, hunting turtles for eggs or meat), as are some natural or non-anthropogenic factors that affect turtles (e.g., predators). In other instances, strict categorization as anthropogenic vs. non-anthropogenic may be inaccurate. For example, human activities can alter or destroy sea turtle habitat in a manner that creates downstream effects that manifest as disease or diminished quality or availability of food. These secondary effects can seem "natural" without additional context. Such linkages can be difficult to study and conclusively demonstrate, especially in marine animals that spend their lives largely unobserved by humans. Although we follow the common convention of distinguishing between natural and human factors in this chapter, we note instances where there is evidence that underlying anthropogenic influences also play a role in seemingly natural threats (e.g., sea level rise, climate change).

Sea turtles take decades to reach maturity (Chapter 1). Most sea turtles do not survive to adulthood and many perish within the first years of life. Chances of survival increase as turtles grow, gaining protection afforded by larger size and increased ability to evade predators. Sustainability of sea turtle populations relies on high survivorship of large turtles that make up the breeding population. Anthropogenic sources of mortality are especially harmful to sea turtles when they cause losses of adult and near adult turtles, which take many years to replace. However, significant and persistent losses of any life stage eventually will negatively affect populations. For example, sustained egg harvest by humans has been implicated as a primary cause for population declines of some species, such as leatherbacks, green turtles, and olive ridley turtles in the East Pacific. All sea turtles within the U.S. are *threatened* or *endangered* under the Endangered Species Act (Chapter 1), which means that they may be more vulnerable than non-imperiled populations to mortality caused by either anthropogenic sources or natural phenomena.

Various factors that influence the health and mortality of sea turtles are generally discussed in this chapter with reference to specific life stages that are affected. The relative importance of each factor varies among individual sea turtle species. Endangered species recovery plans characterize these threats and their significance for individual populations and management units and serve as the foundation for conservation efforts (See "Further Reading").

Natural Mortality Factors

Natural threats to sea turtle survival refer to factors that they would face whether or not humans exist. However, human activities can exacerbate the effects of these natural factors or can make sea turtles less resilient to natural threats.

Environmental phenomena

The earliest life stages of sea turtles are especially vulnerable to environmental phenomena such as weather and coastal processes. High tides and storm surges – including those associated with hurricanes – can erode beaches and wash away nests. Accretion (widening or deposition) of beaches may cause nests to become buried or hatchlings entrapped. Coastal development and loss of dune systems also can destructively alter nesting beaches by interrupting the natural cycle of sand erosion and deposition.

Once sea turtles hatch from their eggs and enter the ocean, they are vulnerable to strong shoreward winds and storms as they struggle to swim to offshore habitat. Unfavorable conditions can wash them back to shore, leaving leave them weak and stranded on land.

Another environmental condition that can cause stranding and death of sea turtles is cold-stunning, a phenomenon that occurs when turtles (with the exception of leatherbacks) are within water temperatures below 10˚C for a prolonged period (Figure 2.1). Relatively shallow bays, sounds, and lagoons, especially those with predominantly northerly access and egress, are most susceptible. The earliest recorded events date back to the 1800s, and sites within the U.S. where cold-stunning events have occurred repeatedly and recently include Cape Cod Bay (Massachusetts), Long Island Sound (New York), inshore waters of North Carolina, St. Joseph Bay (Florida), Mosquito Lagoon and Indian River Lagoon (Florida), and estuary waters of Texas. Larger events can involve hundreds to thousands of sea turtles, many of which would perish without human intervention.

Cold-stunning - A condition in which sea turtles become weak and lethargic, caused by prolonged exposure to water temperatures below 10° C.

A prolonged winter freeze along the Texas coast in February, 2021, resulted in the largest cold-stunning event for sea turtles recorded in the U.S. since at least 1980. Approximately 13,000 sea turtles, mostly green sea turtles, are known to have stranded associated with this event. Many of these turtles were found dead due to the unusual severity of the winter weather, although over 4,000 were successfully rehabilitated and released.

Figure 2.1. Cold stunned green sea turtle. Photo: National Park Service, Padre Island National Seashore.

Predators

All life stages of sea turtles may be killed by predators. Various terrestrial predators, such as raccoons, foxes, coyotes, crabs, armadillos, and ants, excavate turtle nests and feed on eggs and hatchlings. However, some of the most devastating examples are predators introduced by humans, such as dogs and pigs. Extensive losses have occurred on some beaches requiring protection efforts in the form of predator removal and use of protective cages around nests.

*Figure 2.2. Jaguar (*Panthera onca*) and green turtle (*Chelonia mydas*) at Tortuguero National Park, Costa Rica. Photo: Benjamin Barca, Global Vision International (GVI).*

Another interesting example of a terrestrial predator is jaguars (*Panthera onca*), which commonly feed on nesting female turtles in Latin America (Gulder et al., 2015) (Figure 2.2). An investigation by Veríssimo et al. (2012) in Tortuguero National Park in Costa Rica, which hosts both nesting sea turtles and a population of jaguars, found predation on turtles to be increasing. Human encroachment on, and the fragmentation of jaguar habitat were hypothesized to be drivers of this increase.

Newly hatched turtles are vulnerable to many predators, including ghost crabs and birds, as they crawl from their nest to reach the sea. Once in the water, birds and predatory fish consume many hatchlings, and continue to pose threats, especially during the first months of life.

As might be expected, the risk of being eaten by predators decreases with the size of turtles. Sharks remain a potential threat to all sea turtles, even adults (Fig. 2.3). Strandings of turtles with shark bite wounds and live turtles with healed injuries from previous attacks are observed relatively frequently. Other aquatic predators recorded to feed on sea turtles include killer whales and crocodiles.

*Figure 2.3. A great white shark (*Carcharodon carcharias*) attacking a green turtle (*Chelonia mydas*) off Isla Guadalupe, Mexico. The turtle suffered a damaged shell but swam away from this encounter. Photo courtesy of and © Dr. Theresa Guise.*

Harmful algae blooms

Some marine microorganisms (dinoflagellates and diatoms) are capable of producing potent biotoxins that adversely affect marine animals, including sea turtles. These toxic organisms increase in abundance forming *blooms* referred to as *harmful algae blooms* (HABs), although most are not true algae. Some blooms of either toxic or non-toxic species visibly discolor the water, the common term red tide being perhaps one of the most well-known examples. Blooms naturally occur as a result of upwellings (rising of cold seawater to the surface) and other oceanographic phenomena, but also may be caused or worsened by anthropogenic factors, such as eutrophication, overfishing, and climate change.

Exposure to biotoxins, including brevetoxins, paralytic shellfish poisoning (PSP) toxins (includes saxitoxins), and domoic acid, has been reported in sea turtles. Effects have been most clearly demonstrated for brevetoxin and PSP toxins, which primarily affect the nervous system and have been associated with sea turtle mass stranding and mortality events on the Northwest Atlantic coast of the U.S., the Pacific coast of Central and South America, and in Papua New Guinea. Within the US, *Karenia brevis* blooms (a form of red tide) are a frequent cause of sea turtle mortality in Florida's Gulf coast (Foley et al. 2019). Sea turtles are exposed through ingestion of contaminated food. Associated die-offs often involve multiple types of marine animals, including fish, birds, and mammals. Reported strandings of sea turtles coincident with individual HAB events have numbered in the tens to hundreds of animals.

HAB - Harmful algal bloom, a phenomenon caused by a number of phytoplankton groups producing different toxins that can adversely affect a number of organisms, including sea turtles

Disease

Many different forms of disease caused by microorganisms and parasites have been described in sea turtles and are most often encountered when ill turtles are found washed ashore. The underlying cause(s) of many examples is unknown; however, others, especially infections caused by bacteria and fungi, occur secondarily in turtles that are debilitated by traumatic injuries and other underlying factors. In addition, sea turtles are hosts for many parasites, some of which may cause illness and death. A notable example is blood flukes or spirorchiid trematodes, which are common in some regions. These parasites live in the heart and blood vessels and a number of studies have examined their effects on sea turtles. Another parasite, a protozoan called *Caryospora*, infects the intestine and other organs, and is the only reported infectious cause of sea turtle die-offs. Although the volume of literature on diseases of sea turtles has grown substantially in recent decades, there remains a very limited understanding of how disease influences sea turtle populations.

Fibropapillomatosis - A disease of sea turtles that causes skin tumors and is thought to be viral

Fibropapillomatosis (FP) is perhaps the most well recognized disease of sea turtles and manifests as the formation of cauliflower-like tumors on the skin (Fig. 2.4). It is primarily a disease of green turtles, but has been documented to a much lesser extent in other species. It is a transmissible disease and evidence to date suggests that FP is caused by a herpesvirus. In addition, ecological co-factors, including anthropogenic habitat degradation, are suspected to play a role in the development of the disease. Although FP certainly has some negative influence on some green turtle populations and was once believed to potentially threaten survival of the species, numbers of green turtles within the U.S. rebounded after turtle hunting was discontinued, despite the continued presence of the disease. Nonetheless, FP remains a significant concern with regard to sea turtle health due its high rate of occurrence in some localities, ongoing spread into new areas, and its potential environmental quality implications.

Figure 2.4. Green sea turtle with severe fibropapillomatosis in Hawaii. Photo: J. Lynch, National Institutes of Standards and Technology.

Anthropogenic Mortality Factors

Figure 2.5. Sea turtles caught in a gillnet off the coast of Brazil. Photo courtesy of Projeto TAMAR, Brazil.

Fisheries bycatch

Incidental capture (bycatch) of sea turtles in commercial and artisanal fisheries is perhaps the most pervasive and important threat to sea turtle populations globally. Although bycatch affects all sea turtle populations to some extent, the threat is especially acute for some critically endangered populations, such as leatherback and loggerhead turtles in the Pacific Ocean. Sea turtle bycatch occurs in a wide variety of fishing gear; turtles can be caught by hooks, entangled in nets or ropes, and entrapped underwater in trawls, nets, and other gear (Figure 2.5). Furthermore, gear that is lost or discarded into the environment poses a persistent, cumulative risk to sea turtles and is one of the deadliest forms of marine debris created by humans. Sea turtles also are incidentally captured by recreational fishermen and become entangled in their lost or improperly discarded fishing tackle. The scale of sea turtle bycatch by recreational fishermen generally is much lower than that resulting from commercial or artisanal fisheries, but can be substantial in some coastal areas.

Interactions between turtles and fishing gear can result in death or impairment from drowning or injuries. An unknown number of turtles that are released alive die later from delayed or persistent health problems resulting from capture. In addition to risks associated with drowning and different types of trauma, it has now been shown that sea turtles are susceptible to the effects of decompression (the bends) after being caught and brought to the surface, a problem that may further affect survival following capture.

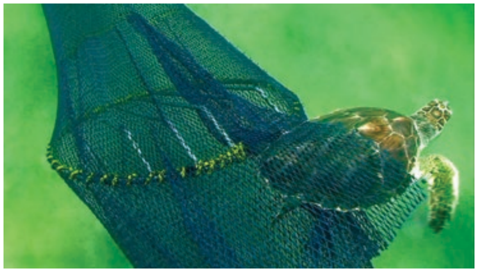


Figure 2.6. A sea turtle escapes from a trawl net through a turtle excluder device (TED). Photo: NOAA.

There have been notable gains in mitigating bycatch in some fisheries. Turtle excluder devices (TEDs) used in the U.S. and other countries have significantly reduced the numbers of turtles killed in trawl nets used to harvest shrimp, the single greatest source of bycatch-related mortality worldwide (Fig. 2.6). Other examples of strategies that been implemented to protect turtles include modification of gear or bait to reduce the severity or frequency of injury and closure of areas to fishing during times when turtles are more likely to be caught.

Although the U.S. and other countries have adopted efforts to reduce sea turtle bycatch, the broad ranges of sea turtles across multiple geopolitical boundaries create a number of challenges for managers because many countries lack similar protective measures. International agreements, such as the Inter-American Convention (IAC) for the Protection and Conservation of Sea Turtles, and those related to fisheries management specifically include bycatch reduction measures that help extend protective measures to large areas that turtles reply upon for foraging, migration, and reproduction.

Hunting of sea turtles and their eggs

Turtles are taken opportunistically as fisheries bycatch, intentionally hunted in the water, or, in the case of adult females and eggs, intercepted on nesting beaches. Killing sea turtles and collection of their eggs is illegal in the U.S., where poaching occurs relatively infrequently. In other areas of the world, collection of turtles and eggs is more commonplace due to lack of laws prohibiting the practice or inability to provide adequate enforcement. For example, indigenous communities in Nicaragua legally hunt sea turtles within their territories; however, illegal harvesting of turtles outside these communities in the same country is virtually unregulated. The nutrition or income obtained from taking turtles and eggs (Figure 2.7) is an overwhelming incentive within poor areas that presents significant challenges to turtle protection efforts.

Major products derived from sea turtles and widely traded prior to implementation of protection measures in the 1970's included meat and calipee (the soft tissues of their lower shell), which were eaten, and bekko (tortoiseshell) from the shells of hawksbill turtles that was used to make jewelry, combs, and other items. International trade of these materials among many countries was prohibited under CITES (Chapter 1). Much of the existing trade and consumption of sea turtles (illegal and legal) occurs within or among neighboring countries of Central and South America, Southeast Asia, and Africa.

Figure 2.7. Turtle eggs for sale in a Malaysian market. Photo: Zulfachri Zulkifl/Shutterstock.

In Costa Rica, while the taking of sea turtle eggs has been illegal since 1966, a controversial exception that became law in 2005 allows restricted collections in Ostional, which hosts large arribadas of olive ridley turtles. Tens or even hundreds of thousands of female turtles nest synchronously on a relatively small section of beach over a few nights. Because this kind of high-density mass nesting results in disruption of previously established nests, hatching success is reduced—by some estimates, more than 95 percent. The overt disruption/destruction of previously laid eggs led University of Costa Rica biologists and government authorities to recommend a limited community harvest of eggs during the first 36 hours of an arribada. However, the practice and the assessments on which it was originally based have not been universally accepted and embraced (Valverde, 2007), and it is not clear how or if the collections affect the reproductive success of the sea turtles.

Figure 2.8. Olive ridley arribada at Ostional, Costa Rica, November 2006. Photo: Valverde (2007).

Disturbance and alteration of nesting beaches

A number of human activities on nesting beaches may affect adult females, eggs, and hatchlings through loss of habitat or disruption of nesting or the ability of females and hatchlings to reach the sea. Sand beaches tend to be high-value property subject to development and frequent human use, which creates a number of challenges in terms of managing them as an ecologically sensitive habitat.

Figure 2.9. Turtle nesting beach in North Carolina where homeowners placed sandbags to halt erosion, rendering previous nesting sites inaccessible. Photo courtesy of Matthew Godfrey, North Carolina Wildlife Resources Commission.

Beach armoring, such as seawalls, rock revetments, and sandbagging installed to protect oceanfront property, creates obstacles that prevent females from accessing nesting beaches (Figure 2.9). In some areas, sand may erode away completely on the ocean side of manmade structures, leaving no nesting beach at all. Where erosion is extensive, property owners or government agencies may try to restore the beach by replenishing the sand from offshore or inland sources, an approach called beach renourishment. While preferable to beach armoring, beach renourishment can create additional problems if sand is used that lacks the necessary physical properties or is leveled incorrectly. Poorly renourished beaches can be too compacted for turtle nesting, form steep escarpments (vertical eroded areas created by waves), or negatively affect incubating turtle eggs.

Nesting females and hatchlings are adapted to navigating nesting beaches under natural, low light conditions. Lights on nearby buildings and roads can deter females from nesting, and cause disorientation of nesting females and hatchlings, preventing them from finding the ocean. An unfortunate example occurred in September, 2009, when a man proposing to his fiancée on Hilton Head Island, SC, placed 150 luminary candles on the beach and inadvertently caused the death of 60 or more loggerhead hatchlings when the couple retired but did not extinguish the candles. Disoriented turtles can succumb to exhaustion, dehydration, hyperthermia, and predation, or may become entrapped in manmade structures or injured or killed by vehicles; in the Hilton Head case, hatchlings circled the candles, were preyed upon by crabs, or moved in the wrong direction, away from the water.

A number of other common human uses of nesting beaches create problems for sea turtles. Beach furniture (e.g., chairs, umbrellas) and other items left on beaches can deter nesting females, impede hatchlings during their crawl to the sea, or obstruct turtles' access to nesting areas or the water. Beach driving not only risks running over nesting turtles, nests, and hatchlings, but it also creates ruts in the sand that can entrap and disorient hatchlings. Even seemingly minor activities during nesting seasons, such as holes excavated by beachgoers, can have fatal consequences for turtles.

Persistent threats from erosion, artificial lighting, heavy beach usage, and other problems—including the DWH oil spill—have been used to justify relocating nests to other beach sites, or to hatcheries. While the practice may save threatened nests, it is important to note that relocation typically decreases nest success compared to nests left in place. This discrepancy is due to changes in incubation conditions, mortality during the move, and problems such as increased predation at release sites. Thus, nest relocation is viewed by many experts as a short-term intervention that is necessary in some situations, but should not be considered a sustainable long-term management solution.

Vessel traffic and dredges

Commercial and recreational vessel traffic can overlap extensively with sea turtle habitat. An unfortunate consequence is that vessel strikes (Figure 2.10) are a relatively frequent occurrence in some regions where dead or injured turtles are commonly found as beachcast strandings. Many turtles struck and killed by vessels are larger juvenile and adult turtles, which removes reproductively valuable individuals from the population.

Figure 2.10. Green turtle with fractured carapace from vessel propeller. Photo courtesy of Adrienne McCracken, Loggerhead Marinelife Center.

Dredges are used to collect large volumes of sediment from the ocean floor in order to maintain navigable waterways and harbors for vessels or to build up land or beaches. Some types of machinery commonly used in this process, such as hopper dredges, can incidentally capture or kill sea turtles. During active dredging operations, hopper dredge dragheads sweep across bottom sediments, suctioning them into holding compartments (hoppers) where they are held for subsequent release at a disposal site. The draghead moves slowly and relatively quietly, and turtles can be entrained with serious consequences (Figure 2.11). As protective measures, dredging may be avoided when sea turtles are most abundant within an area, dredge machinery can be modified or operated in a manner to try to prevent capture of turtles, or sea turtles can be relocated from the dredge path using trawlers and trained personnel that capture turtles by deploying their nets for short periods to prevent drowning.

Figure 2.11. Olive ridley turtle suspected to have been killed by a hopper dredge (background) in Rio de Janeiro State, Brazil. Photo courtesy of Daphne Wrobel Goldberg.

Pollution and marine debris

Numerous chemical pollutants and inestimable volumes of solid manmade debris have been dumped into the ocean or made its way there through run-off or atmospheric routes. Sea turtles may suffer adverse health effects directly or indirectly through degradation of habitat, prey, or forage. One of the most notable examples of the latter is eutrophication caused by widespread use of fertilizers and discharge of organic material into inshore waters. Ecological impacts manifest as algal blooms, loss of marine vegetation and invertebrates though diminished light penetration and oxygen, and proliferation of opportunistic or invasive species. In addition, potential linkages between anthropogenic effects on the environment, such as pollution, and sea turtle health concerns (HABs, disease) are mentioned above.

With the exception of oil spills, which is of course our focus here, the effects of chemical pollutants on sea turtles are poorly understood. Although a number of studies have examined exposure of sea turtles to various contaminants, including heavy metals and persistent organic compounds associated with pesticides and other products, much less is known about the implications of these exposures on sea turtle health. Significant challenges that preclude the use of many basic toxicological research tools include the protected status of sea turtles, their relatively long lifespans, and their ocean-going life history that keeps them largely out of reach for researchers. Moreover, effects of many pollutants can be very chronic, highly complex, and thus inherently difficult to study. Scientists interested in examining health effects of chemical contaminants are forced to rely heavily on extrapolation of information from other, often very different animals.

Figure 2.12. Hawksbill turtle entangled in plastic lines and fishing net. Photo courtesy of Chris Johnson, Loggerhead Marinelife Center of Juno Beach, Florida.

Discarded solid material, referred to as "marine debris," causes more readily demonstrable effects on sea turtles. Marine debris includes the universe of discarded objects made from plastic or other material (often broken down into unrecognizable form), derelict fishing gear, and every other form of refuse. Turtles will readily ingest foreign items because of their indiscriminate feeding behavior or because they confuse such objects with food. Ingested debris can obstruct or injure the digestive tract or reduce the nutrient intake of growing turtles. Linear debris, such as fishing gear (monofilament lines, rope, discarded nets), can entrap turtles, preventing them from reaching the surface or causing strangulation of flippers (Figure 2.12). Marine debris also can be deposited in abundance on nesting beaches, rendering them unusable by sea turtles.

Climate change

There are several potential impacts of climate change on turtles and their habitats. For example, increases in sand temperatures can cause developmental abnormalities, reduce the number of male turtles, or even cause embryos to die. Sex determination in sea turtle hatchlings is temperature dependent, with lower temperatures producing males and higher temperatures producing more females. Studies have shown that even small elevations in temperature by less than a few degrees can significantly alter the proportions of male and female hatchlings.

The rise in sea level that is predicted to occur with climate change brings with it a number of other potential risks to sea turtles. Sea level rise increases the risk of saltwater inundation of nests, which can be lethal to developing eggs, and is especially a concern for lower profile beaches used by sea turtles. Nesting in suboptimal areas and fewer numbers of successful nests may result. On a shorter-term basis, increased storm frequency and intensity may alter nesting habitats and behavior, as well as the diet and home ranges of sea turtles. Storms inundate nests with saltwater, expose or wash away eggs, and can even destroy – at least temporarily – entire nesting beaches. For example, in 2018, Hurricane Walaka wiped away many of the sand islets of French Frigate Shoals, which is the predominant nesting area for green turtles in the Hawaiian Islands. Such storms on a more frequent basis or with greater intensity than historical levels could diminish successful nesting to a degree that negatively impacts sea turtle populations.

These effects of climate change are anticipated to be synchronous, cumulative, and influenced by many factors. A model-based study of green turtles in the northern Great Barrier Reef region predicts that nesting beaches closer to the equator would suffer the greatest consequences of climate change; and while sea level rise would initially affect nesting success (by 2030), the longer-term effects of rising temperatures would ultimately be of greater consequence for this population.

In addition, climate change impacts on sea turtles may be exacerbated by other threats. For example, alterations and degradation of suitable nesting or foraging habitats due to coastal development and construction, or bycatch in fisheries, could make sea turtle populations less resilient to negative effects of climate change. As is the case with all imperiled resources, it is difficult and probably unwise to consider specific individual risks in isolation from the entire suite of threats facing sea turtles. While we focus on oil in this document, the reader would be best-served by considering risks to sea turtles posed by oil spills within this broader context.

Table 2.1. Relative impacts of anthropogenic threats on sea turtle population in U.S. jurisdiction, based on a global assessment of all sea turtle populations (Wallace et al. 2011). If the impact of a threat on a population was scored "high," the type of threat was specified. DD: data deficient. Note: The assessment was performed before injury from the Deepwater Horizon *oil spill was determined.*

	Loggerheads		Greens				Leatherbacks		Hawksbills			Kemp's ridleys	Olive ridleys
	NW Atlantic	N Pacific	NW Atlantic	S Caribbean	E Pacific	N Central Pacific (Hawaii)	NW Atlantic	W Pacific	W Atlantic Caribbean	E Pacific	N Central Pacific (Hawaii)	NW Atlantic	E Pacific
Fisheries bycatch	High	High	Low	Low	Medium	Low	High	Medium	Medium	High	Low	Medium	High
Examples:	longlines, trawls, gillnets	longlines, gillnet					gillnets			gillnets, bomb fishing			longlines, trawls
Take (Turtles/ Egg)	Low	Medium	High	High	Low-Medium	Low	Low	Medium	High	High	Low	Low	High
Examples:			nesting females; adults & subadults	nesting females; adults & subadults				eggs; nesting females; adults & subadults	eggs; adults & subadults				eggs; nesting females; adults & subadults

Table 2.1 continued.

	Loggerheads		Greens				Leatherbacks		Hawksbills			Kemp's ridleys	Olive ridleys
	NW Atlantic	N Pacific	NW Atlantic	S Caribbean	E Pacific	N Central Pacific (Hawaii)	NW Atlantic	W Pacific	W Atlantic Caribbean	E Pacific	N Central Pacific (Hawaii)	NW Atlantic	E Pacific
Coastal Development	Medium	High	Medium-High	Low	Medium	Low	Low	Low	Medium-High	Medium	Low	Medium	Medium
Examples:		beach armoring											
Pollution & Pathogens	DD	DD	Low-Medium	DD	DD	DD	Low	DD	DD	Low	DD	Medium	Low
Examples:													
Climate Change	DD	DD	Low	High	DD	Medium	DD	DD	High	DD	DD	Medium	DD
Examples:				sea level rise					coral bleaching, acidification, sea level rise				

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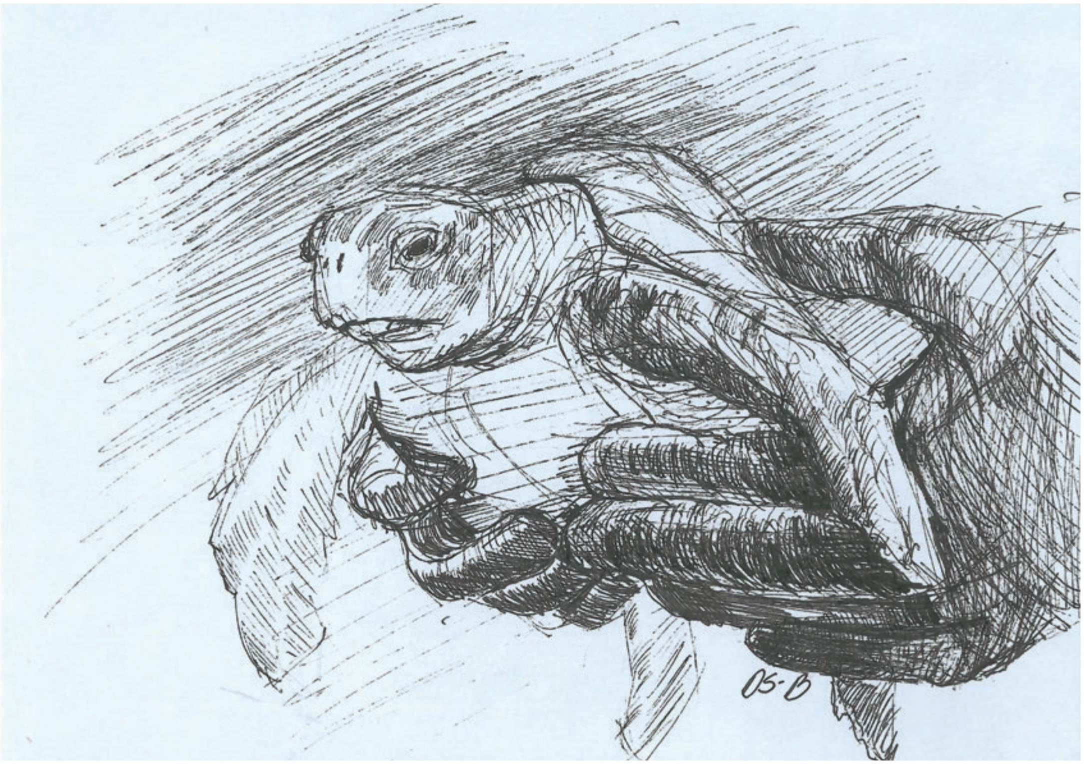
Chapter 3. Oil Exposure and Effects on Sea Turtles



Debra Simecek-Beatty

Key Points

- Areas of oil and gas exploration, transportation, and processing often overlap with important sea turtle habitats.
- Several aspects of sea turtle biology and behavior place them at risk of oil exposure during spills on land and at sea, including dependence on nesting beaches, lack of avoidance behavior, reliance on oceanographic features that tend to accumulate oil, propensity for accidental ingestion, and specific sensitivities of some life stages.
- All sea turtle life stages are vulnerable to a range of lethal and sublethal effects of oil.

- Susceptibility to these effects is influenced by the timing, location, and conditions of exposure, and the physical and chemical characteristics of the specific type of oil.

Introduction

This chapter provides a broad overview of oil exposure and potential risks to sea turtles. There is a necessary degree of generalization; however, oil is a complex mixture of thousands of chemicals, each of which has its own inherent physical, chemical, and toxicological properties. The effects on sea turtles during a given spill depend upon the specific characteristics of the petroleum (or other chemicals) that has been released, the nature of exposure, and many other considerations.

Figure 3.1. Stranded olive ridley sea turtle during 2017 oil spill near Chennai, India. Photo: courtesy of International Tanker Owners Pollution Federation (ITOPF).

Much of the world's oil and gas exploration, mining activities and transportation of products occur in the oceans, creating an inevitable risk for marine life and the environment. Sea turtles and other marine animals are exposed to anthropogenic sources of oil through spills that range in magnitude from large-scale disasters, such as those seen in the Gulf of Mexico and Persian Gulf, to smaller discharges from vessels, machinery, and petroleum infrastructure such as pipelines and platforms. Oil spills, especially larger ones, tend to gain the most attention due to the often-alarming imagery that accompanies them. However, more frequent and diffuse sources of petroleum pollution also are important. For example, ingestion of floating tar balls, which arise from both natural (oil seeps) and human sources, has long been recognized as a threat to smaller sea turtles. Although the relative impacts of oil spills on sea turtles are presumably less than those of other well-recognized anthropogenic threats, such as bycatch in commercial fisheries and hunting of turtles and their eggs (see Chapter 2), local and regional effects from oil spills can be devastating and take an additional toll on already imperiled sea turtle populations. Also, the enormous scale and magnitude of hydrocarbon extraction, production, and transport around the world make oil pollution and associated effects a constant yet frequently overlooked threat to sea turtles.

Our understanding of the effects of oil on sea turtles is primarily gleaned from observations during spills, examinations of oiled turtles found stranded on coastlines, and a very limited number of laboratory studies. Because sea turtles are legally protected and are relatively large, long-lived, ocean-going species, it is extremely challenging to determine effects of oil through scientific study; thus, a number of knowledge gaps exist. Freshwater turtles and some other aquatic animals have been studied far more extensively and are used as surrogates for sea turtles. Although extrapolation of information from different animals requires caution, those effects that are consistently observed in a variety of animals also may be predicted to occur in sea turtles. Where relevant, these similarities, as well as apparent differences, are considered in this review.

Where are sea turtles exposed to oil?

All life stages of sea turtles are susceptible to exposure to various forms of oil and its constituent chemicals (Fig. 3.2). Because sea turtles spend most of their lives in the marine environment but nest on beaches, they can be exposed to oil on land as well as in the water. The nature and magnitude of these exposures are influenced by the location and timing of spills. As reviewed in Chapter 1, sea turtles have complex life histories and use various habitats related to factors such as water temperature, availability of food, transitions between different life stages, and reproduction. Known aspects of sea turtle biology allow us to generally predict these movements and anticipate to some degree where and when sea turtles are found, especially within well-studied areas. However, the movements and abundance of some life stages are especially dynamic and are influenced by a number of changeable environmental factors that result in year-to-year variation.

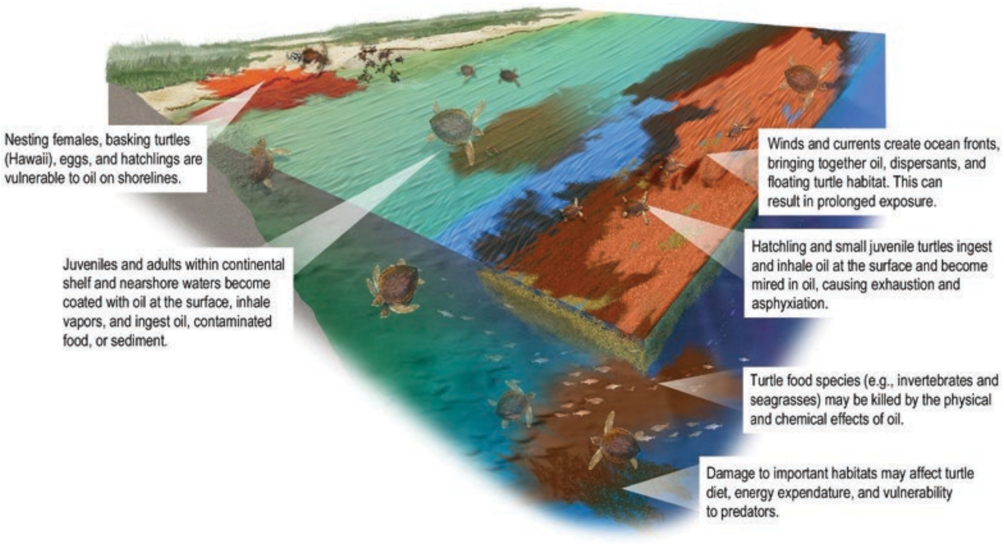


Figure 3.2. Potential routes of exposure to oil and effects in marine and terrestrial habitats. Illustration by Kate Sweeney.

Figure 3.3. Green turtles basking on the bedrock shoreline of Kaloko-Honokohau National Historical Park, Hawaii. Photo: Gary Shigenaka, NOAA.

Nesting beaches

Oil deposited on nesting beaches can expose adult female turtles, incubating eggs, and hatchings. Because females dig their nests and lay their eggs within a chamber, exposure may result from oil that washes onto the beach surface or that percolates into the sand or becomes entrained within deeper layers. Females exhibit strong fidelity to specific beaches or general areas and thus presumably have limited ability to avoid oiled coastlines. They may be deterred from nesting in oiled areas to some degree by response-associated activities such as deployment of oil boom or oil removal, which is another negative consequence of oil spills that will be presented in Chapter 4. Although some nesting occurs year-round in some locations, most nesting occurs within summer months. Therefore, the extent to which adult females, eggs, and hatchlings are exposed depends on when oiling occurs relative to nesting, incubation, and hatching.

In addition, green turtles in Hawaii and other areas of the Pacific bask on shorelines unrelated to reproduction (Figure 3.3). These turtles also are susceptible to oil on coastlines and exhibit fidelity to specific basking locations.

Figure 3.4. Oiled Kemp's ridley sea turtle captured in a Gulf of Mexico convergence zone during the 2010 Deepwater Horizon *spill. Photo: Blair Witherington, Florida Fish and Wildlife Conservation Commission.*

Marine environment

In the water, sea turtles do not appear to avoid oil actively based on limited laboratory studies (e.g., Lutcavage et al., 1995). Furthermore, there are numerous recorded observations of turtles in oil during actual spills. All turtles must surface to breathe, potentially forcing them into direct contact with floating oil and resulting in various potential routes of exposure. Hatchlings and smaller juvenile turtles are especially vulnerable to floating oil because they spend much of their time at the sea surface and frequently associate with oceanographic features called convergence fronts or frontal zones, which are created by currents and wind. These areas accumulate floating habitat, which include *Sargassum spp.* (a type of seaweed or marine algae) in the Atlantic Ocean, as well as anthropogenic debris and petroleum (Figure 3.4; Chapter 1; Figure 1.2; Chapter 4). Sea turtles also can be exposed to oil in the water column, on the seafloor, or within sediments as they swim and forage (Figure 3.2).

How are sea turtles exposed to oil?

Exposure to oil occurs through external contact, ingestion, and inhalation. Because most exposures under natural conditions result from a combination of routes, most of which have not been studied individually, it is not possible to confidently parse out their relative importance other than in general terms, e.g., exposure in fully formed sea turtles vs. during embryonic development. Multiple studies have measured *polycyclic aromatic hydrocarbons* (PAHs), the most well-studied toxic constituents of oil, in tissues of sea turtles exposed to petroleum from known spills as well as undefined sources. Absorption and metabolism of PAHs by sea turtles also has been demonstrated (Ylitalo et al., 2017).

PAHs - polycyclic aromatic hydrocarbons, a class of chemicals found in oil most often associated with toxicity

Direct contact with the skin and mucous membranes of turtles, or with the shells of eggs is the most visible route of exposure. Petroleum readily adheres to keratinized epithelium, the layer of cells that forms the outer skin and lines the mouth and esophagus, leading to both persistent dermal exposure and ingestion (Figures 3.5 and 3.6). Sea turtles are known to frequently ingest oil during spills. For example, most oiled sea turtles examined during the *Deepwater Horizon* spill had oil within their mouth or esophagus, including over 90% of the more heavily oiled animals (DWH NRDA Trustees, 2016).

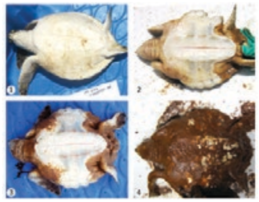


Figure 3.5. Direct observations of oil on sea turtles during the Deepwater Horizon *oil spill. Various degrees (1-4, minimal, light, moderate, and heavy) of oil exposure documented in rescued turtles. Photos: Brian Stacy/ NOAA.*

Sea turtles may ingest oil incidentally with contaminated water or food, but also may intentionally eat aggregated weathered forms of oil, such as tar balls, as a consequence of indiscriminate feeding behavior or because they mistake it for prey. Tar balls within pelagic habitat have long been regarded as pervasive threat to small turtles, but ingestion of various forms of oil has been documented in turtles of all sizes. There is little information on the risk of ingestion posed by petroleum within the water column or seafloor. Notably, loggerhead and Kemp's ridley sea turtles dig into bottom sediments to find invertebrate prey (Chapter 1), potentially exposing them to buried or sunken oil.

Figure 3.6. Mouth and esophagus of sea turtles during Deepwater Horizon *response showing obvious ingestion of oil. The image on the right shows the sharp papillae of the esophagus, which are present in all sea turtles, coated with oil. Photos: Brian Stacy/NOAA.*

Sea turtles breathe at the water's surface, where they are at risk of inhaling volatile chemicals and aspirating aerosolized droplets of oil. Like marine mammals, the specialized diving physiology of sea turtles may enhance their absorption of these compounds, residual particulates from burnt oil, or chemical dispersants remaining after application. Inhalational exposure has the potential to be continuous for turtles within larger spills, spills that encompass foraging areas or other extensively oiled habitat, such as convergence zones. PAHs have been detected in lung tissue of oiled sea turtles but the toxicokinetics of inhalation and its effects have not been specifically studied.

Another potential, but largely uninvestigated route of exposure is passage of PAHs and other chemical constituents of petroleum from female turtles to their eggs during development. Many of the known toxic constituents of oil, such as PAHs, are *lipophilic*, i.e., they readily associate with fatty or lipid-rich tissues, such as body fat, the liver, and yolks of developing eggs. Pesticide and polychlorinated biphenyl residues have been detected in sea turtle eggs (Clark and Krynitsky, 1980), but at low concentrations relative to birds and terrestrial reptiles. Sea turtles form yolk while they are feeding at their foraging areas during the year preceding nesting. Yolk formation is already complete by the time they arrive at nesting beaches, which can be far away from foraging locations. This distance in time and location of yolk formation and egg laying would affect the degree to which maternal transfer may occur – and be detected – under various circumstances of oil exposure.

Adverse effects of oil on sea turtles

The effects of oil on sea turtles are considered here from two general perspectives: physical and chemical. There is considerable potential for overlap and synergy among processes that may be considered primarily physical or chemical in terms of their mechanisms of action and resulting effect; however, this distinction allows us to more clearly convey our current understanding and identify areas where knowledge gaps persist.

Physical effects include interference with movement, thermoregulation, feeding, breathing, vision, and evasion of predators. These effects also often involve physiological responses that can negatively influence health and survival, such as stress response and energy expenditure. Chemical effects are caused by toxic compounds that make up oil and directly injure cells, cell components, or interfere with processes related to cell function, such as metabolism and replication. Much of the known chemical toxicity of oil is caused by PAHs and their derivatives that are formed during metabolism by biological systems.

Weathering - The physical, chemical, and biological processes that act to change oil in the environment

The type of oil and its degree of *weathering* – i.e., the alteration of both physical and chemical characteristics by environmental processes – influence both its physical features and toxic potential. For example, refined products, such light fuel oils, and non-weathered oil have lower viscosity (the resistance of a fluid to change its shape) and are more likely to contain volatile chemicals that are inhaled. Weathered crude, bunker fuel oils, and various forms of marine tar are thick and more likely to physically impair movement or function. Most documented reports of sea turtles and oil have involved these heavier forms, which is attributable to the frequency and scale of such spills and accelerated weathering processes in the warmer waters favored by sea turtles. It is important to recognize that the range of physical and chemical characteristics of oil may substantially influence the suite of effects resulting from exposure to a given product and may explain some of the differences in effects described in various reports.

The most apparent and well-characterized effects of oil on sea turtles are physical. As described in Chapter 1, hatchlings and small juvenile turtles spend nearly all of their time at the surface and thus are vulnerable to becoming mired in thick oil or tar (Figure 3.7). For relatively small animals, this physical fouling can encumber their movement and lead to complications, such as entrapment in harsh environmental conditions (e.g., high or low temperatures), overexertion, interference with feeding and hydration, and asphyxiation by aspiration of oil. Tar balls and other thick, tenacious forms of oil can obstruct the mouth, hinder or prevent it from opening, or create blockages within the digestive tract. Larger sea turtles spend less time at the surface and are assumed to be more physically capable of overcoming restrictions in movement created by fouling, but it is noteworthy that larger oiled turtles have been encountered as strandings. In these cases, impairment may be to some extent physical in nature.

Figure 3.7. Heavily oiled Kemp's ridley turtle recovered during the Deepwater Horizon *at-sea response. Photo: Tomo Hirama (Florida Fish and Wildlife Commission).*

Much less is known about the chemical effects of oil on sea turtles. Very few experimental studies have been conducted. Documented instances of field exposures often lack detail or clear explanation of physiological or toxicological mechanisms to explain reported adverse effects or specific observations. In addition, very few turtle studies have considered the effects of dispersants, which have been shown to affect the bioavailability of PAHs to some organisms (e.g., invertebrates, larval fish), especially those in the water column (Allan et al., 2012; Wolfe et al., 2001). Some of this incomplete information has been bridged by extrapolating the toxic effects of oil on other animal taxa to anticipate potential effects on sea turtles.

One of the few laboratory studies that examined oil effects on sea turtles (Lutcavage et al., 1995) exposed juvenile loggerhead turtles to crude oil for two weeks and reported skin lesions, decreased salt gland function, and alteration of some blood cell parameters. Due to the paucity of direct experimental studies of oil and turtles, these results are widely cited in the literature. However, dermatological effects and evidence of diminished salt gland function were not observed in loggerhead and Kemp's ridley sea turtles that were exposed to crude oil during the *Deepwater Horizon* spill. In the latter example, most of the abnormalities in oiled turtles were alterations of blood parameters attributable to stress response and the physical effects of fouling and capture. A subsequent laboratory study (Mitchelmore et al., 2015) examined the effects of ingested *Deepwater Horizon* oil on two species of freshwater turtles over a two-week period. Some sublethal effects were detected, including oxidative stress, dehydration, and potential alteration of gastrointestinal function, although no exposures resulted in mortality. Another *Deepwater Horizon* laboratory study (Harms et al., 2014) exposed loggerhead hatchlings to crude oil with and without dispersant for 1 to 4 days, and the hatchlings failed to gain weight in both exposure groups, a result which was consistent with decreased seawater consumption and dehydration. Hemolytic anemia and Heinz body formation resulting from oxidative damage to red blood cells, which has been described in oiled birds, have not been observed in oiled turtles.

Various pathological findings have been reported in oiled loggerhead and Kemp's ridley sea turtles detected as strandings, including necrosis (death of cells and tissues) and inflammation of the skin, gastrointestinal lining, liver, and kidneys. Abnormal changes in blood parameters have also been reported in stranded oiled turtles. In contrast, the aforementioned evaluation of numerous oiled sea turtles during the *Deepwater*

Horizon spill did not find evidence of specific tissue toxicity and attributed most of the observed effects to physical fouling. These inconsistencies may reflect differences in dose and duration of exposure, characteristics of various types of oil, potential confounding health problems that are frequently observed in stranded sea turtles (e.g., dehydration, poor nutritional condition, infections), and the non-specific nature of many of the reported observations. One consistency was that most oiled turtles that were found alive survived following removal of oil and clinical treatment; compassionate intervention that is not afforded to the vast majority of sea turtles exposed to oil.

With regard to effects of oil on developing embryos, more information is available for estuarine and freshwater turtle species than for sea turtles. Even so, relatively little research has been conducted on turtles, especially in comparison to bird studies. Exposure of freshwater turtle eggs to sediments contaminated with petroleum (or PAHs derived from petroleum) has been associated with higher deformity rates and decreased hatching success under some conditions (Van Meter et al., 2006). In contrast, one study (Rowe et al., 2006) that exposed artificial nests containing snapping turtle eggs to surface oiling, with and without dispersant, measured no biological effect, noting that percolation of product through the nest substrate altered the chemical nature of the oil. In the only published study of oil effects on sea turtle eggs (Fritts and McGehee, 1982), non-weathered oil was shown to be more toxic to embryos than weathered oil, suggesting that adverse effects are dependent upon the degree of weathering.

Most studies of turtle eggs have focused on the chemical effects of oil and toxicity, but physical alteration of nesting substrate and the incubation environment, as well as interference with the respiratory function of egg shells also could be important. Thus, similar to the effects on other life stages, a number of factors, including characteristics of the product, nesting substrate, environmental conditions, and timing of exposure, likely influence how oil affects developing sea turtles.

Many of the physical and chemical effects of oil mentioned thus far are relatively amenable to study because they can be measured using readily available methods and tend to be observed within hours to weeks following exposure. In contrast, there are a host of potential chronic and indirect effects that are challenging to study in long-lived, late-maturing, ocean-going species such as sea turtles. Long-term effects on growth rates, foraging success, predator avoidance, physiological performance, and reproduction are significant, population-scale considerations. These more cryptic but potentially substantial effects of oil exposure remain largely unexplored. In addition, some specific effects have been raised as potential concerns for sea turtles, but data currently are lacking. For example, olfaction is important for navigation, orientation, and foraging, and could be disrupted by chemical contaminants such as oil. Also, petroleum has been shown to affect function of the adrenal glands in a wide variety of other animals, from fish to mammals, but this has not been conclusively studied in any turtle species. Another example is the potential effects of petroleum on commensal bacterial communities, such as those responsible for digestion in herbivores, such as green turtles. Researchers (Wikelski et al., 2002) have speculated that interference with gut fermenting bacteria caused by chronic oil exposure led to a decline in marine iguanas (*Amblyrhynchus cristatus*), another herbivorous reptile, following an oil spill in the Galapagos Islands.

Another important consideration is impacts of oil on habitat and other organisms that sea turtles reply upon for food and shelter. Losses of seagrasses, floating *Sargassum spp.* communities, wetland vegetation, nesting beaches, and numerous types of invertebrates have been demonstrated and could have significant indirect effects on sea turtles. In general, the downstream consequences of habitat and prey alterations for reliant species often do not receive much specific attention, but nonetheless may significantly contribute to the full gamut of oil spill effects.

When the first edition of this response guide was published in 2003, much of what was known about the effects of oil on sea turtles derived from just a few laboratory studies and investigations using surrogate animals. The *Deepwater Horizon* experience, as appalling and tragic as it was, vastly increased our level of understanding about the intersection of oil spills with sea turtles. This can only benefit the kind of veterinary and response actions we anticipate and undertake as we move into an industrial energy future that still includes petroleum in its portfolio.

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Chapter 4. Response Considerations for Sea Turtles

Debra Simecek-Beatty

Key Points

- Spill responders must carefully consider vulnerabilities of sea turtles to both oil and response actions, which are largely influenced by the location and timing of the incidents.
- Many common response actions can impact sea turtles. These require coordination with both resource and operational experts to devise effective avoidance or mitigation measures.
- The risks posed to sea turtles are greatest when turtles are aggregated, such as during nesting season or within important foraging habitats.

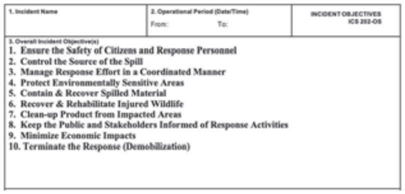
- In offshore spills in U.S. waters, where hatchling and small juvenile sea turtles are found, dedicated rescue efforts can be highly effective and are a recommended response action to minimize effects to these vulnerable life stages.
- Spills that impact or threaten nesting beaches require a number of considerations to minimize harm to female turtles, eggs, and hatchlings.

Introduction and Background

The preceding chapters have introduced us to sea turtles and their unique place in ocean and coastal ecosystems, the risks they face from a myriad of sources, and the recent insights into what we know about their interaction with oil. Now, we will discuss oil spill response, how the actions and methods we consider and adopt as part of a response strategy intersect with impacts to sea turtles, and how we can integrate minimization of sea turtle impacts into the actions that responders implement.

ICS - Incident Command System, the standard oil spill response management structure used in North America

As a prelude to discussing response considerations for sea turtles, it is useful to review the broader objectives of oil spill response. The Incident Command System (ICS), which will be presented in greater detail later in this chapter, is the standard response structure for spill incidents used in North America. Under ICS, explicit response objectives are defined for each spill on an ICS-202 form. An example is shown in Figure 4.1. These objectives are not the same for every spill and may encompass a suite of priority considerations beyond removing and recovering as much of the spilled product as possible.


1. Incident Name	2. Operational Period (Date/Time) From: To:	INCIDENT OBJECTIVES ICS 202-OS

3. Overall Incident Objective(s)
1. Ensure the Safety of Citizens and Response Personnel
2. Control the Source of the Spill
3. Manage Response Effort in a Coordinated Manner
4. Protect Environmentally Sensitive Areas
5. Contain & Recover Spilled Material
6. Recover & Rehabilitate Injured Wildlife
7. Clean-up Product from Impacted Areas
8. Keep the Public and Stakeholders Informed of Response Activities
9. Minimize Economic Impacts
10. Terminate the Response (Demobilization)

Figure 4.1. Example of ICS-202 form for Incident Objectives during an oil spill response. Source: Region 10 Regional Response Team.

There can be unavoidable, incompatible response objectives. For example, the most effective oil cleanup actions may result in harm to natural resources like sea turtles if implemented without consideration of potential impacts. Figure 4.2 is a simple Venn diagram to illustrate potentially competing or conflicting response objectives. The "sweet spot" of overlap in the center would represent response actions that consider the tradeoffs associated with objectives. Discussions of competing features such as these are at the heart of preparedness efforts like contingency or response plans, or comparative impact assessment activities such as Net Environmental Benefits Analysis (NEBA) or Spill Impact Mitigation Analysis (SIMA).

When a spill in U.S. waters occurs, the Emergency Response Division (ERD) of NOAA's Office of Response and Restoration (OR&R) supports the U.S. Coast Guard and other agency responders. NOAA Scientific Support Coordinators (SSCs) provide scientific information to the Incident Commander and Unified Command and may conduct shoreline assessments, aerial overflights, trajectory modeling, and identification of resources at risk. SSCs also regularly participate in National and Regional Response Team planning activities, assist in the development of Area Contingency Plans, provide planning and response tools for local and regional decision makers, and conduct training to facilitate more effective spill response. If a spill occurs in an area where sea turtles may be at risk, the Incident Commander (typically through the NOAA SSC) will contact the NOAA National Marine Fisheries Service (NMFS) Office of Protected Resources to activate wildlife response specific to sea turtles. As noted in Chapter 1, NOAA and the U.S. Fish and Wildlife Service (USFWS) share federal jurisdiction for sea turtles; thus, USFWS is engaged simultaneously. Depending on the scale of the incident and the sensitivity of the potentially affected turtle species and habitats, sea turtle responders may deploy on-scene to integrate into the Wildlife Unit of the response.

Figure 4.2. Venn diagram illustrating response objective tradeoffs and selection of a preferred strategy.

The shared jurisdiction for sea turtles in the U.S. is detailed in a 2015 Memorandum of Understanding between the USFWS and the NMFS (USFWS and NMFS, 2015). In general, USFWS jurisdiction is terrestrial, and that of NMFS is marine; there are, however, some areas of exception that are described in the Memorandum. For example, NMFS administers the Sea Turtle Stranding and Salvage Network (STSSN) that handles distressed or dead sea turtles both in the water or on the beach, although USFWS is directed to assist NMFS with the STSSN. The Memorandum of Understanding between USFWS and NMFS is included in this document as Appendix A for reference.

OPA 90 - Oil Pollution Act of 1990, the primary federal law governing oil spill response in the U.S.

Under the Oil Pollution Act of 1990 (33 U.S.C. §2701 et seq.), which governs and structures much of the federal oil spill response activity in the U.S., responsibility for acting on behalf of the public lies with designated federal, state, tribal, and foreign natural resource trustees. These trustees are authorized to assess and restore natural resource injuries resulting from a discharge of oil, or the substantial threat of such a discharge, and associated response activities. The National Oil and Hazardous Substances Pollution Contingency Plan (commonly referred to as National Contingency Plan, or NCP), designates NOAA and agencies within the U.S. Department of the Interior, including the USFWS, as federal trustees for a wide variety of coastal resources, including fisheries, migratory birds, protected species (including sea turtles), and habitats (e.g., wetlands, mangroves, mudflats, beaches, and reefs). State resource agencies also serve as co-trustees for sea turtles in state waters and lands. The Oil Pollution Act also directs trustees to evaluate the need for, and complete if warranted, a Natural Resource Damage Assessment (NRDA) to return injured natural resources and services to the condition they would have been in if the incident had not occurred, and recover compensation for interim losses. During a spill incident, response and NRDA assessments involve similar and possibly overlapping field and data collection activities. However, because the underlying mandates and objectives are different, they are managed and implemented independently.

NRDA - Natural Resource Damage Assessment, the process to determine the appropriate restoration needed to offset impacts to fisheries, wildlife, habitats, and human uses caused by oil spills and other environmental incidents

NOAA and the USFWS also share trustee resource responsibility under Section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 et seq.) (ESA) to address any potential impacts of a spill response on sea turtles and their critical habitats. Area contingency planning must consider possible impacts to endangered and threatened species from response activities, and how to avoid or minimize them through such actions as conservation measures. During an actual response, emergency ESA Section 7 consultations between representatives of the Incident Command and the trustee agencies are held to consider specific response actions and how they might impact federally protected species (Figure 4.3).

In 1989, sea turtle physiologist Peter Lutz wrote, "…the potentially harmful effects of an oil spill on sea turtles must clearly be taken seriously, and any strategy to prevent turtles from encountering the oil must be regarded as a preferred frontline defense." Preventing turtles from encountering oil is the preferred and logical strategy, but is not necessarily easy, or even possible in many cases. Moreover, some actions that are com-

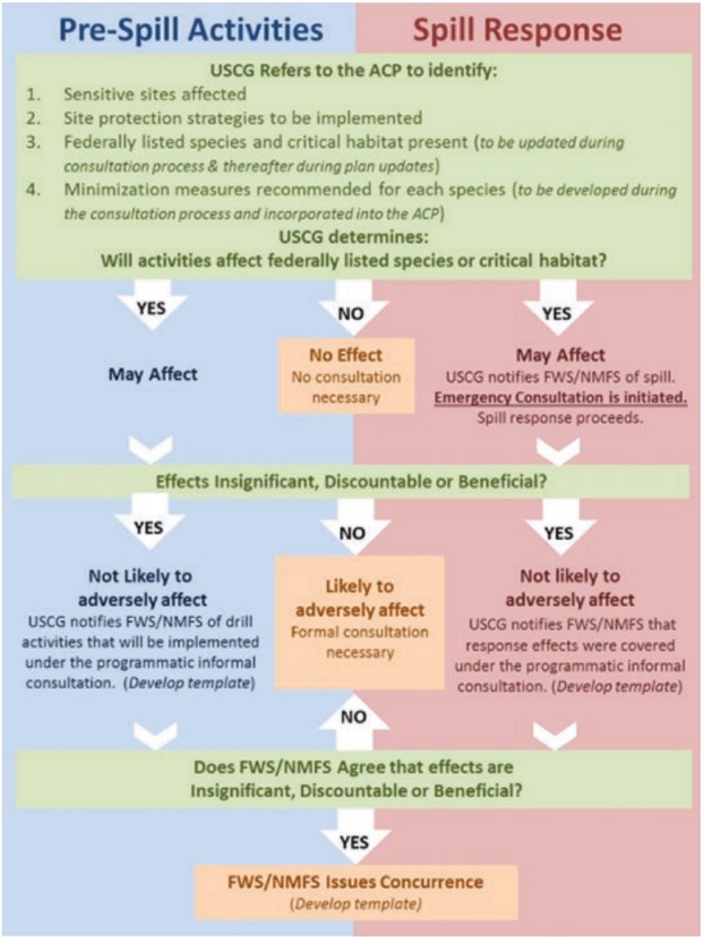


Figure 4.3. Schematic for Endangered Species Act Section 7 consultation process, pre-incident and during an emergency. USCG = U.S. Coast Guard; ACP = Area Contingency Plan; FWS = U.S. Fish & Wildlife Service; NMFS = National Marine Fisheries Service. Source: Regional Response Team IX.

monly employed to remove or displace oil or protect sensitive areas, such as controlled burns or deployed oil boom, can have unintended impacts on sea turtles and other natural resources. Those responding to oil spills or planning response actions should be aware of the risks posed to sea turtles, and should consider those mitigating actions that are possible or practicable. Fortunately, knowledge has been gained during previous oil spills that can inform and guide these efforts.

Responses to oil spills depend on the type of oil spilled and the environment at risk. The general features of spill response equipment and strategies for its use are described in many other publications (see, for example, https://www.itopf.org/knowledge-resources/documents-guides/response-techniques/). Rather, in the sections to follow, we will provide some basic information on response activities considered from the perspective of possible effects on sea turtles and their habitats.

Sea Turtle Response and the Incident Command System (ICS)

The impacts of an oil spill can vary widely, from isolated incidents that are contained on-site to incidents that have a local, regional, national, or international impact. Contingency plans are developed to address specific geographic and resource characteristics of an area. Such plans identify and facilitate the coordination of the different government agencies and private organizations authorized to act on behalf of the government in the response. They can include notifications of key agencies and personnel, and ultimately result in a series of remedial actions to recover released petroleum from a spill source and minimize harm to affected habitats. In North America, oil spills are managed under the ICS, a standardized approach to the command, control, and coordination of an emergency response that was adapted from wildfire fighting. One of the advantages of the ICS is that it is adaptable and scalable, making it ideal for managing responses to spills of any kind of oil in virtually any environment.

Within the ICS, response activities for sea turtles and other wildlife are typically directed by the Wildlife Branch, in the Operations Section (Figure 4.4). The Wildlife Branch oversees response activities and information collection for birds, marine mammals, sea turtles and other species affected by a spill. Response is coordinated across resources, particularly where response activities are implemented in areas where multiple species co-occur and might be affected simultaneously. Wildlife operations targeting specific taxa (e.g., sea turtles) may opportunistically assist or document those for other animals (e.g., birds) and should have the necessary operational flexibility and appropriate permits and instructions.

If sea turtles are affected by an oil spill, a Sea Turtle Group may be activated within the Wildlife Branch. As with other aspects of spill response, the size and complexity of this group and its operations will depend on the magnitude of the spill and risks to

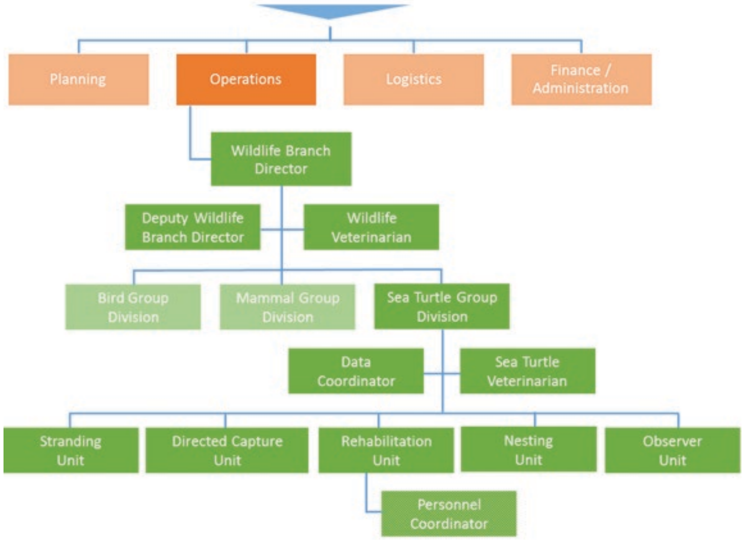


Figure 4.4. Example organizational chart of an Incident Command Structure for an oil spill affecting sea turtles. A Personnel Coordinator may be needed for large units and is shown here under the Rehabilitation Unit as an example.

specific life stages and habitat. The Sea Turtle Group would typically be staffed by state and federal trustees with specific expertise in sea turtle response and would likely be led by NOAA or DOI. The group may have a physical presence within the Incident Command Post or remotely coordinate activities as appropriate. Responsibilities include developing and implementing sea turtle aspects of a response plan and ensuring timely mobilization of necessary personnel and equipment.

Once the Wildlife Branch and Sea Turtle Group are activated, field response activities may be initiated, including: reconnaissance to determine what sea turtle species and habitats are at risk; search and rescue for live and dead oiled sea turtles; monitoring of sea turtle nesting and protection of nests; treatment and rehabilitation of oiled sea turtles; release of recovered sea turtles; and other response activities, as needed.

In-situ burning - response technique in which spilled oil is burned in place.

BMPs - Best Management Practices, the preferred practices, methods, actions, materials and other items that avoid and minimize impacts to ESA-listed species and their critical habitat

In addition to the sea turtle response efforts that are directed by the Wildlife Branch, other critical actions related to sea turtles may occur within the Environmental Unit of the Planning Section. The Environmental Unit provides Best Management Practices (BMPs) for minimizing impacts to sea turtles from oil response activities, (e.g., *in-situ* burning and deploying boom), and monitors the compliance with BMPs by response personnel. Many oil spill response activities have the potential to negatively affect sea turtles, and the implementation of BMPs into response operations are employed as a mechanism to reduce effects. BMPs are generally required as part of the Emergency ESA Section 7 consultation for the response.

Exposure and Risk: Planning and Assessment

A basic component of the early stages of an oil spill response is the assessment of resources at risk, i.e., given the circumstances of the incident, what organisms and habitats might be in harm's way? In the U.S., the NOAA SSC is responsible for providing such a summary to the U.S. Coast Guard unit overseeing the initial response activities. Typically, this is a rapidly generated and relatively simple cataloguing of animals and plants that are expected to occur in the area affected or forecast to be affected by the spill, with an estimate of impact based on what is known about the petroleum product that has been released. The description of resources at risk provided by the SSC or other resource agencies represents an overview of environmental sensitivity or vulnerability information that is intended to be the basis for a more detailed and robust assessment generated through discussions with regional experts and resource agencies, as well as representatives of an Environmental Unit that may be established as part of the formal response structure under the ICS.

In the preparation of Area Contingency Plans and Geographic Response Plans, during drills and exercises, and during an incident of sufficient magnitude where a Unified Command has been formed, sensitive resource descriptions (including biological, archeological, tribal, cultural, and socio-economic) are formalized and captured in the ICS-232 form, Resources at Risk Summary. In a spill incident, the Environmental Unit Leader has the responsibility for completing the ICS-232 for each operational period with input from resource trustees. The Environmental Unit Leader forwards the form to the Planning Section Chief, and the form is usually integrated into the Incident Action Plan. In the ICS structure, the ICS-232 form provides a consistent "parking place" for resources at risk information so that new response personnel can acquaint themselves with resources priorities for the operational response area.

Environmental Sensitivity Index Maps

A spill response tool developed and supported by NOAA is the Environmental Sensitivity Index (ESI) map, which conveys geomorphology (shoreline characteristics) and resource information (both natural and human) for an area through color variations and icons for groups of plants and animals and human uses. While ESIs have many applications unrelated to spill response, they represent a quick-reference tool for non-specialist responders who have a need or desire to understand the physical and biological setting for an incident.

Sea turtles are found on the ESI maps for many U.S. coastal regions, particularly along southern coastlines. The maps identify nesting beach areas, in-water distribution, shoreline habitats, species composition, seasonality, relative concentration, nesting

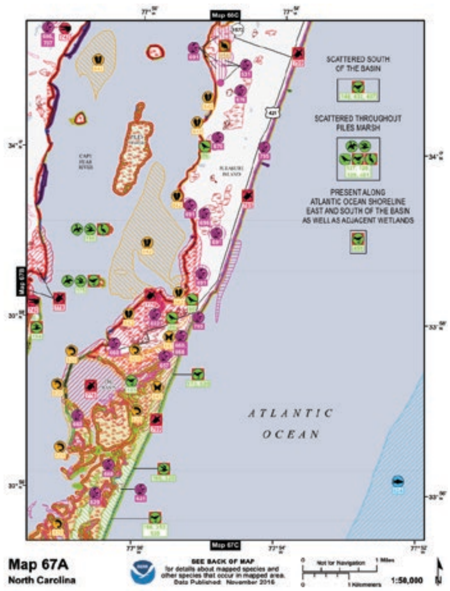


Figure 4.5. Example of ESI map produced for coastal North Carolina showing known sea turtle distribution and habitat locations. ESA-listed species are highlighted in red. Source: NOAA.

beach survey boundaries, and source documentation. Much of the information is provided by state biologists and resource managers. Figure 4.5 is an example of the resultant product. As shown on the ESI map, species listed under the ESA, such as sea turtles, are highlighted as red icons.

With the advent of georeferenced mapping data and the ability to rapidly produce custom products, the ESI data permit targeted resource-specific queries from which specialized maps can be produced to aid and guide responders in planning for nearshore and shoreline assessment and cleanup activities.

ESI maps are static and generalized snapshots for resources in a given area. However, there can be sufficient detail in the underlying data to portray specific information, such as seasonality, specific species distributions and habitat use, and/or life stages. However, ESIs are likely most useful in depicting general, relatively predictable information for well-studied coastal or nearshore areas, such as nesting and seasonal movements. Largely pelagic species and life stages that are more dynamic and wide-ranging, and poorly studied areas, are not well represented in ESI data.

In most areas of the country, ESI maps are integrated into more sophisticated geographic information systems and mapping tools, such as NOAA's Environmental Response Management Application (ERMA). This permits ESIs to be viewed with many other types of real-time, georeferenced, and visual information such as ship locations, weather, ocean currents, and satellite imagery, enhancing their power and utility.

Additional sea turtle planning and response references: NRDA Guidelines

NOAA recently published *Guidelines for Oil Spill Response and Natural Resource Damage Assessment: Sea Turtles*, a comprehensive resource for spill response and NRDA (Stacy et al., 2019). These guidelines incorporate knowledge gained from previous oil spills, especially the 2010 *DWH* spill. They include essential tools and information pertinent to sea turtles found within U.S. waters to aid planning and preparation for future oil spills, guide effective spill response, and facilitate damage assessment. These guidelines provide additional details including in-depth information and lessons-learned, e.g., for NRDA specialists and wildlife professionals involved in response activities.

Effective oil spill response and NRDA requires early identification of species and life stages at risk, timely deployment of knowledgeable personnel and other assets, efficient preparation of emergency responders, and—especially for NRDA—judicious collection of information that will only be available during and shortly following a spill. Tools available to understand the magnitude of risk and potential injuries to sea turtles as a result of an oil spill include: consistent surveys of nesting beaches and marine habitats (e.g., vessel-based and aerial) to document sea turtle presence, abundance, and oil exposure; evaluation of oiled turtles and nests encountered during rescue efforts, stranding response, and other activities to document exposure and effects (including those caused by response activities); and for larger spills, integration of field observations, remote sensing data, and other information over time to evaluate the magnitude and persistence of injuries to sea turtles and their habitats. The NOAA Guidelines provide detailed information and guidance for the rigorous assessments needed for NRDA; there is, however, extensive overlap in the methods and approaches suitable for both response actions and NRDA. An example of this overlap was seen during the *DWH* response, when aerial surveys that began early in the incident under the umbrella of response were continued virtually unchanged by the NRDA to monitor animal distribution and abundance during and following the spill.

In U.S. waters, there typically is enough basic information about occurrence and habitat use to predict which turtles might be at risk at a given time of year from an oil or hazardous chemical release, as well as the subsequent response to it. Appendices 2 and 3 of the NOAA Guidelines provide temporospatial information about distribution, relative abundance, and nesting for different portions of the U.S. coast to help responders understand potential impacts to sea turtles. Additional appendices of the Guidelines offer general operational information, draft data forms and protocols, and Best Management Practices (BMPs) created by resource experts during recent oil spills (*DWH*, Texas City Y) for adaptation to future incidents. These Guidelines are not intended to be strictly prescriptive, rather to serve as a planning resource and supplementary information. Federal and state resource managers and other regional wildlife experts should be consulted for current conditions and turtle-related considerations for specific spills before any response operations are mounted.

At the state level in the U.S., standardized methods for sea turtle nesting surveys are available, for example, the "Marine Turtle Conservation Handbook" (https://myfwc.com/media/3133/fwc-mtconservationhandbook.pdf) is the document that defines the approach used in Florida. Although this reference is not specific to oil spills and provides specific guidance for those personnel authorized to perform sea turtle-related activities, the handbook includes detailed material that could be useful for permitted spill response and shoreline survey activities, nesting surveys, and identification of nesting sites.

Overview of Open-Water Response Methods

Oil can be released into offshore waters by accidents involving vessels, pipelines, and oil production platforms. Naturally occurring seeps, routine vessel operations, and, occasionally, intentional illegal dumping, also contribute to the volume of oil introduced

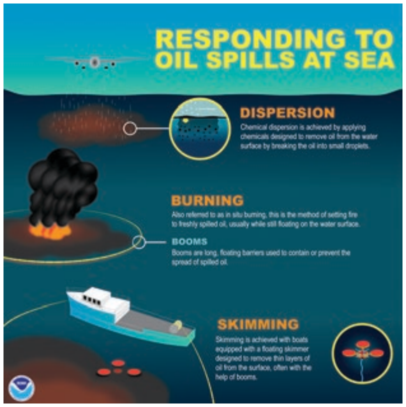


Figure 4.6. Three primary response approaches for open-water environments. Graphic by NOAA.

into the ocean. Regardless of source, when the amount of oil on the water is deemed to be a threat to the environment, efforts are mobilized to reduce that volume. In this section, we will provide brief overviews of the primary methods used to respond to oil spills in open water and discuss the implications for sea turtles that inhabit the waters where these incidents occur.

Open-water oil spill response methods most commonly include containment and recovery approaches such as booming and skimming. Techniques such as burning and the use of chemical dispersants, which attracted a great deal of attention during the *DWH* incident, have been infrequently, even rarely, employed. Figure 4.6 is an illustration of the three major open-water response approaches.

Offshore Mechanical Recovery

Spilled oil on water can be contained and collected using equipment such as booms and skimmers. When successful, these mechanical methods result in the removal of oil from the marine environment, allowing for either safe disposal or recycling of the recovered product. During many spills, mechanical collection is relied upon as the primary on-water cleanup method, but experience has shown that mechanical recovery alone cannot always deal with large offshore spills. Containment booms, an integral component of open water mechanical recovery, do not perform well in heavy waves, in shallow waters, or in swift currents—an estimated 58 percent of all spills occur in water moving over 1 knot (PMG, Inc., 2001). In addition, emulsified oil that co-mingles with debris or is highly weathered is difficult or impossible to recover by skimming.

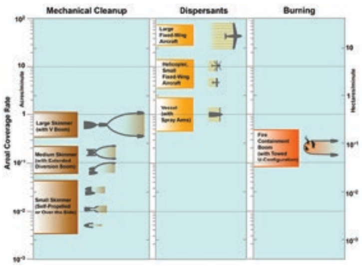


Figure 4.7. Comparison of areal coverage for different on-water response methods, a key element of spill response encounter rates. Source: Allen (1988); graphic by Kate Sweeney.

Even under ideal circumstances, mechanical recovery may not successfully control large spills or oil that has spread over large areas. A fundamental concept underlying oil spill response in open water is that of *encounter rate*; that is, how much of an oil spill is encountered by any given response technique. Regardless of the method being considered for an open-water response, the volume encounter rate will depend upon the system's swath (i.e., the width of its passage through or over oil), its *speed* while accessing the oil, and the average *thickness* of the oil encountered (Figure 4.7). The realities of ocean sea conditions and the physics of oil behavior on water conspire to reduce the effective encounter rates for mechanical cleanup methods. That is, as spilled oil spreads across the surface of the water, it becomes increasingly difficult for a response asset to contact recoverable volumes of oil. Figures 4.8a and 4.8b show satellite views of the *Deepwater Horizon* slick and response vessels attempting to collect oil. Given the surface area of the oil slick, any effort to contact and recover oil during a large spill such as this is extremely challenging and typically inefficient.

The theoretical effectiveness of mechanical oil recovery equipment and techniques under controlled conditions is often substantially reduced by the operational realities of sea state, oil viscosity, and capacity for recovered oil storage—among other considerations. Estimates of real-world recovery efficiencies from the sea surface rarely exceed 10-15 percent (Wadsworth, 1995; International Tanker Owners Pollution Federation, 2015); in the *DWH* spill, only 2-4 percent of the total spill volume was estimated to have been skimmed by the largest fleet of specialized oil recovery vessels ever assembled (Federal Interagency Solutions Group, 2010).

Threats to turtles imposed by the use of oil containment boom and oil skimming equipment are determined by the location and timing of intended deployment. For example, towed boom and skimming within offshore areas might incidentally encounter small oceanic sea turtles that spend most of their time at the surface, especially if the animals are entrained in oil that is being removed. Under other circumstances, these impacts may be minimal. In either case, consultation with resource experts and careful monitoring for turtle activity is essential throughout a spill response in known sea turtle habitat, which encompasses a large proportion of U.S. waters during most of the year. Crews of response vessels should be provided with best management practices that explain the potential presence of sea turtles and provide them with necessary instructions in the event that turtles are encountered. Deployment of trained wildlife observers authorized to locate and handle sea turtles may be necessary under some circumstances.

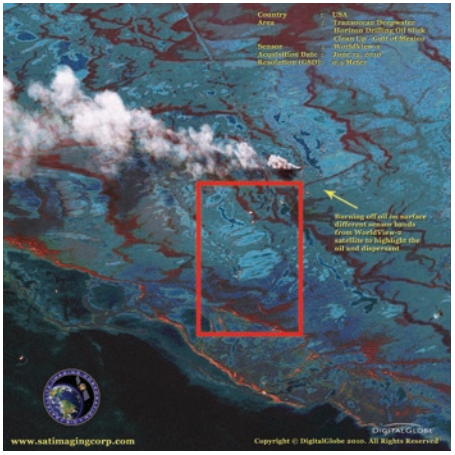


Figure 4.8a. Satellite photo of Deepwater Horizon *response activities in the Gulf of Mexico on June 15, 2010. Smoke plume denotes* in-situ *burn operation. Highlighted rectangle shown in greater detail in Figure 4.8b. Photo used with permission of* Spatial Imaging Corporation *and MAXAR DigitalGlobe.*

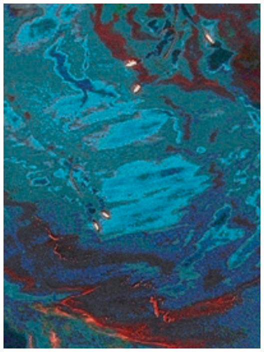


Figure 4.8b. Detail of area highlighted in Figure 4.8a, showing vessel skimming activity. Satellite photo of Deepwater Horizon *response activities in the Gulf of Mexico on June 15, 2010. Smoke plume denotes* in-situ *burn operation. Highlighted rectangle shown in greater detail in Figure 4.7b. Photo used with permission of* Spatial Imaging Corporation *and MAXAR DigitalGlobe.*

Offshore Dispersant Application

When mechanical approaches to recovery of spilled oil are judged to be inadequate relative to the volume of oil on the water or potential environmental impacts, alternative open-water response techniques, such as chemical dispersant application or *in-situ* burning of oil on water, may be considered for a number of reasons: e.g., to reduce the presence of oil on the sea surface, the time that it remains there, the formation of tarballs, and the risk that oil will reach shore. As a rule, methods such as aircraft-applied dispersants or *in-situ* burning have higher encounter rates than mechanical skimming, and thus offer the tactical advantage of potentially removing more oil. However, the conceptual and practical disadvantage of these response methods is that unlike skimming, the oil is not recovered and removed; some portion is transferred to the water column or to the atmosphere.

Chemical dispersants are mixtures that, when applied to floating oil slicks, reduce the interfacial tension of oil, enabling it to be broken into fine droplets that move into the water column where they can be reduced in concentration and subjected to processes of microbial degradation. Most oils will physically disperse naturally to some degree, without the addition of dispersants, from agitation created by wave action and ocean turbulence; chemical dispersants are designed to enhance this natural process. Rapidly dispersing oil early in a spill reduces the oil on the water surface and thus the amount of oil available to be brought ashore. Oil droplets dispersed in the water column are less likely to strand ashore because they are primarily distributed by currents, not winds. An additional potential benefit of dispersing oil is that dispersants inhibit the formation of tarballs, a known ingestion hazard for organisms including sea turtles.

Figure 4.9. Aerial dispersant application from a Basler BT-67 fixed wing aircraft during Deepwater Horizon *spill, May 2010. Photo: Petty Officer 3rd Class Stephen Lehmann, U.S. Coast Guard.*

Dispersants are typically sprayed directly onto floating oil as fine droplets, either from aircraft (Figure 4.9) or vessels, generally within the first hours or days of a spill. The imperative to act quickly stems from the fact that oil is chemically dispersed most effectively when it is less spread out and less weathered. Under appropriate conditions, lighter fuel to medium crude oils can be easily dispersed, whereas dispersants are less effective for heavier intermediate and bunker oils. Weathering increases oil viscosity and may cause formation of water-in-oil emulsions, which reduce dispersant effectiveness. Among the advantages of dispersants are that they can treat large areas of spilled oil quickly and efficiently before the slick can spread significantly (i.e., higher encounter rate), they can be applied in weather and sea conditions unsuitable for mechanical recovery methods, and they can be used in areas too remote for mechanical protection and cleanup. In response to the *DWH* oil spill, which resulted in approximately 134 million gallons (507 million liters) of oil being released into the Gulf of Mexico, a total of 1.84 million gallons (nearly 7 million liters) of two types of chemical dispersants (Corexit 9527 and Corexit 9500) were applied to surface waters and injected directly into the wellhead on the sea floor.

Ideally, chemical dispersants should be applied in well-mixed waters, where the dispersed oil plume can be diluted to low levels that increase the rate of biodegradation before potentially reaching coastlines and nearshore waters. After dispersion into the water column, spreading or diluted oil becomes three-dimensional in its distribution, and concentrations drop rapidly. The highest concentration of chemically dispersed oil typically occurs in the top meter of water during the first hour after treatment. During some historical dispersant field trials, concentrations of oil in the upper 2 m peaked at 50 parts per million (ppm) immediately following treatment. However, concentrations greater than 1 part per million of chemically dispersed oil were rarely documented at 1 and 10 meters below treated oil slicks during the *DWH* spill. Within minutes following dispersant applications in the Gulf of Mexico, the maximum oil concentration at 1 m was 5 ppm and the average 0.96 pm; at 10 m below treated slicks there were no increases above background oil concentrations (Bejarano et al., 2013).

Dispersed oil droplets are ultimately broken down by natural processes such as biodegradation, which occurs more rapidly than the weeks to years required to biodegrade undispersed oil. The chemical dispersants themselves, like the oil droplets, are diluted by diffusion and convective mixing, and also readily biodegrade. Potential benefits of dispersant use for sea turtles include: dispersed oil may be less likely to reach nesting beaches, oil is less likely to aggregate into thick, heavy collections at the sea surface that can mire sea turtles, and dispersed oil may not adhere as readily to sea turtle skin.

On the other hand, smaller dispersed oil droplets may also be more bioavailable, and thus potentially more easily incorporated into marine organisms and food webs. The toxicity of dispersant formulations and dispersed oil has been a controversial topic. Unfortunately, little is known about the toxicological effects of dispersants on sea turtles, and such impacts are difficult to predict without direct testing or targeted sampling of turtle habitats in which oil has been chemically dispersed. As discussed in Chapter 3, a laboratory study following the *DWH* spill exposed loggerhead hatchlings to the dispersant Corexit 9500A and demonstrated alteration of blood chemistry values and inhibited weight gain. While inhaling petroleum vapors can irritate turtle lungs, dispersants may also interfere with normal lung physiology through their effects on surfactant and gaseous exchange — obviously a critical function for diving animals such as sea turtles. Dispersant components absorbed through the lungs or gut may affect a number of other physiological processes, including digestion, hormonal function, and ion balance, similar to the demonstrated effects of oil alone.

Although early dispersants contained components that were highly toxic to some aquatic animals, toxicity has been significantly reduced in modern formulations. However, for fish and other water-column species that were tested during the *DWH* spill, the apparent toxicity of dispersed oil was equivalent to or greater than that for undispersed oil. This is not unexpected, if we assume that dispersants work as intended—i.e., moving more oil into the water column, thereby increasing exposure. Nevertheless, it is clear that more work is necessary to determine potential toxic effects of dispersants and dispersed oil on specific wildlife species of concern. Possible effects on organisms in the water column and tradeoffs among other resources at risk (such as coral reefs and seagrass beds) should be considered in spill response planning and decision-making, and weighed against potential impacts to sea turtles and other animals.

Effective mitigation of any harmful effects of dispersants on sea turtles is challenging and may not be possible in some circumstances. For example, some life stages of sea turtles are too small to be seen from airplanes, which are typically used to search for at-risk marine mammals prior to dispersant applications. Wildlife survey vessels could be deployed to an area being considered for dispersant use, but the operational necessity to quickly treat dispersible aggregations of oil may render pre-application vessel-based surveys impractical.

Despite their recognized disadvantages, chemical dispersants, if applied appropriately offshore, may reduce some of the most apparent impacts to sea turtles caused by surface oil and oiling of nearshore habitat and beaches. Areas of the U.S. that include turtle nesting sites and foraging areas have dispersant contingency plans in place. These plans – for example, the Caribbean Regional Response Team (CRRT) Dispersant Use Plan (CRRT, 2016) – have designated, specific pre-authorized use zones and guidelines for dispersant application that consider the potential presence and habitat use of sea turtles in the region, thus facilitating the decision-making process in the event of a spill. By intent and by design, this plan integrates the consideration of potential sea turtle impacts and provides a framework for considering the use of dispersants in different regions of the Caribbean. The Federal On-Scene Coordinator and other members of the Unified Command would use this as the starting point for specific dispersant use decisions.

Offshore *In-Situ* Burning

In-situ burning is a response technique in which spilled oil is burned in place ("*in situ*", Latin). Under appropriate conditions, *in-situ* burning can remove large quantities of oil quickly and efficiently. Although this method has been effectively used for certain shoreline habitats (e.g., marshes), consideration here is limited to its use on the open ocean. *In-situ* burning has been used much less frequently as an open water response technique, so our empirical knowledge base is limited. However, the 2010 *DWH* spill and its unique circumstances presented the opportunity for use of burning on an unprecedented scale.

Figure 4.10. In-situ *burning operations in the Gulf of Mexico during* Deepwater Horizon *spill in 2010. Photo: Chief Petty Officer John Kepsimelis, U.S. Coast Guard.*

The metrics associated with *in-situ* burns conducted during the *DWH* oil spill (Figure 4.10) were eye-opening. In the first four months of the spill, response personnel conducted 411 controlled *in-situ* burns, including 16 in a single day that consumed approximately 50,000 to 70,000 bbl of oil (Allen et al., 2011). A total of 210,000-310,000 bbl were estimated to have been burned during response operations, a volume that is roughly equivalent to the total amount of oil released during the *Exxon Valdez* spill in 1989.

In a typical *in-situ* burn in open, marine waters, oil is collected within a fire-resistant, u-shaped boom, towed away from the main slick, and ignited once a sufficient volume of oil has been gathered. The oil can be ignited by a number of means, but most simply, a container of combustible fuel such as kerosene is placed in the oil with a road flare igniter. Once the oil fire has been lit, the boom is towed slowly to both contain the oil and maintain an oil thickness sufficient to sustain the burn. Most crude and refined oils will burn on water if the oil layer is at least a few millimeters (more than 2 to 3 mm) thick. The technique is not recommended if winds are blowing harder than 20 knots and seas are higher than 2 to 3 feet, because the vessel operator's abilities to control the boom and maintain the necessary oil thickness are impeded. *In-situ* burning can be used simultaneously with other oil spill response techniques or when other techniques are not feasible. The response window can last several days, although the ability to ignite the oil and the resulting burn efficiency are reduced by significant emulsification, evaporation of lighter and more easily burned volatiles, and spreading of spilled oil. Consequently, burning at sea is most effective early in a spill response.

A major potential advantage of *in-situ* burning is that it can remove over 90 percent of the oil contained in the boom, well exceeding the maximum efficiencies of mechanical and chemical response methods. Burning also requires less equipment and fewer personnel and produces less waste for disposal than other cleanup techniques. In remote areas and near sensitive habitats, where minimizing disturbance is desirable, *in-situ* burning can offer significant logistical and environmental advantages.

Disadvantages of *in-situ* burning include the requirement for expensive high-temperature specialty boom for containment of the burning oil, and the resulting production of thick black smoke and other combustion by-products that can be a concern near more populated portions of the coast. Use of this method may be restricted due to concerns about the effect of fine particulate material in the smoke on human respiratory health. Special Monitoring of Applied Response Techniques (SMART) monitoring protocols (NOAA, 2006) were developed by NOAA, the U.S. Coast Guard, the U.S. Environmental Protection Agency, and the Agency for Toxic Substances and Disease Registry (ATSDR) to monitor particulate levels and provide real-time feedback to responders when burning is conducted near population centers. Such feedback helps responders determine if particulate concentrations exceed established standards, a trigger requiring the cessation of burn activities.

In-situ burning also poses the risk of inadvertent injury or death to marine organisms entrapped within the product that is to be burned, which is a particular concern for sea turtles. As we noted previously, oil tends to aggregate within convergence zones that are likely to be targeted for offshore response operations because of the enhanced encounter rates for surface oil. While this increases the risk that sea turtles might be inadvertently killed by burn operations, ultimately this would need to be weighed against the potential impacts of prolonged or heavy exposure to untreated surface oil in the absence of response actions. Immediate risks to turtles can be mitigated to some degree by deployment of trained wildlife observers, who survey oil for marine animals, including sea turtles, prior to ignition.

While the effects of smoke on sea turtles in particular have not been studied, the effects should be similar for all air-breathing vertebrates. Evaluating human health risk from smoke plumes has focused on inhalation of very fine particulate material (termed

PM2.5, or particulate material less than 2.5 microns in diameter) as the greatest risk factor. Fine particles can become lodged deep within the alveoli of the lungs, compromising respiratory capacity. Because turtles must surface regularly to breathe, they are at risk from inhaling gases and particulates present in a plume near the surface. Another hazard is that burning oil generates a residue that, while representing a small percentage of the original oil volume, has very different physical and chemical characteristics (Shigenaka et al., 2017). These burn residues are often denser than seawater and can sink; methods for collection of burn residues, especially those that sink, are poorly developed. There was no attempt to collect burn residues during the *DWH* spill. Although the volume reduction from unburned to burned oil from those burn operations was estimated to be around 90 percent, the sheer volume of oil burned translated into the generation of approximately 10,000-55,000 bbl of material that mostly sank in the deep waters of the Gulf of Mexico. Under some circumstances, turtles may ingest these residues, just as they are known to ingest tarballs and other materials of human origin they encounter.

Laboratory and field studies of potential physical effects and toxicity indicate that *in-situ* burning does not confer significant adverse effects on the underlying water column beyond those associated with unburned oil. Physically, almost all heat is directed upward and outward, so heat absorbed by the underlying water is generally negligible, particularly where currents continuously exchange water beneath the burn. The fire vaporizes and combusts the lighter chemical constituents of the surface oil that would typically be most likely to dissolve into water and result in acute toxicity to exposed organisms. Laboratory studies (Daykin et al., 1994) conducted in association with the Canadian large-scale Newfoundland Offshore Burn Experiment (NOBE) in 1993 found little toxicity resulted from burning oil on seawater.

Figure 4.11 portrays a decision flowchart for *in-situ* burning that illustrates how wildlife considerations are factored into the overall framework for evaluating use of the technique.

Sargassum spp. *as a response consideration and concern*

A particular habitat found in the Atlantic Ocean (including the Gulf of Mexico and Caribbean Sea) that is of concern for open-water spill response and sea turtles is pelagic *Sargassum spp.* (Figure 4.12), also known as "Gulf weed." *Sargassum* is a floating algae or seaweed that occurs at the ocean surface as clumps, drift lines, and large mats or "rafts" that harbor a unique harbor a unique, dense community of small, cryptic marine organisms, as well as juvenile sea turtles, sport fish (e.g., mahi mahi, billfish, tuna), and pelagic seabirds. *Sargassum* may be present in large concentrations in summer months; however, the amount of pelagic *Sargassum* can be highly variable from year to year and place to place. There are two principal species in U.S waters, *Sargassum natans* and *S. fluitans*.

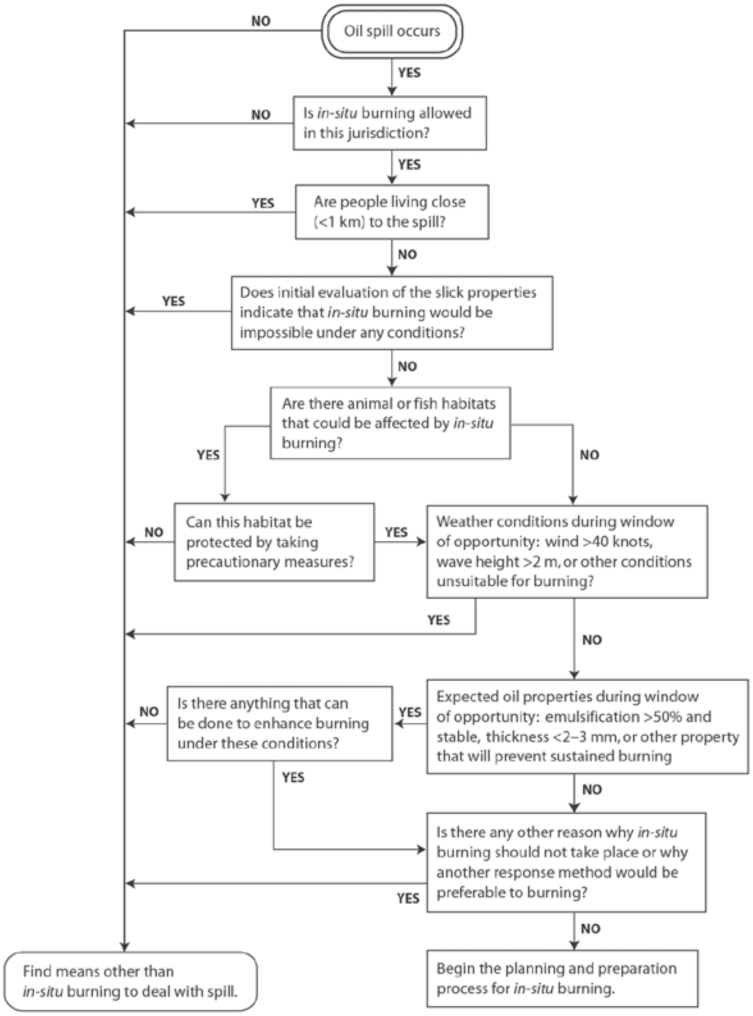


Figure 4.11. Decision flowchart for evaluating in-situ *burning as a spill response option. Wildlife-related consideration points highlighted in yellow. Adapted from U.S. Coast Guard and Environment Canada (1998).*

Sargassum in some U.S. waters is designated as Critical Habitat for loggerhead sea turtles under the Endangered Species Act, particularly for post-hatchlings and juvenile turtles. Other sea turtle species also use *Sargassum* habitat, as detailed in Chapter 1.

Overflight observations are helpful in determining the amount of pelagic *Sargassum* present in an area of concern, although aerial observers must be trained to distinguish *Sargassum* from both oil and other floating material, as they can appear similar at higher altitudes. Because oil slicks at sea and floating *Sargassum* behave similarly with respect to winds and ocean currents, they will aggregate in the same oceanographic features, such as convergence zones or lines. This unfortunate coincidence causes float-

Figure 4.12. Closeup of Sargassum sp., *showing the floats (pneumatocysts) that keep the plant at the surface of the water. Photo courtesy of H. Scott Meister, South Carolina Department of Natural Resources.*

ing oil to contaminate drifting accumulations of *Sargassum* (Figures 4.13 and 4.14). Animals such as sea turtles that associate or depend on *Sargassum* can become fouled in oil, or exposed to oil through inhalation or ingestion.

Oil spill responders, seeking larger aggregations of oil for more efficient collection by skimming, burning, or dispersing, are more likely to encounter sea turtles as they target convergence zones for remedial operations. During the *DWH* spill, collections of pelagic *Sargassum spp.* and oil frequently co-occurred. In that incident response, risks to sea turtles were mitigated to the extent feasible by implementation of a wildlife observer program aboard response vessels. This measure would eventually be further institutionalized in best management practices (BMPs) for the response (Appendix B). These served as the basis for a more detailed set of BMPs found in NOAA (2019) (Appendix C).

Responders deploying offshore countermeasures such as chemical dispersants, mechanical skimming, and *in-situ* burning should take into consideration impacts to *Sargassum* habitat and its associated animals, particularly protected sea turtles. This may include the use of observers and the avoidance or minimization of response actions near concentrations of *Sargassum*. Unless otherwise demonstrated through properly conducted surveys, i.e., from vessels using personnel experienced with spotting small sea turtles, it should be assumed that turtles are likely to be present and at risk. Close coordination with the Wildlife Branch within the Incident Command, and NOAA/NMFS Protected Species specialists is necessary for those overseeing and implementing open water response operations.

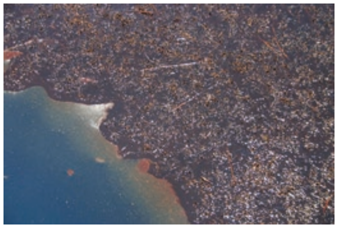


Figure 4.13. Closeup photo of Sargassum and oil along a convergence line in the Gulf of Mexico, 2010. Photo: Blair Witherington, Florida Fish and Wildlife Conservation Commission.

Chemical dispersants could be effective in reducing oiling of *Sargassum* habitat and associated animals, if applied prior to the slicks contacting weed lines or mats. Although limited research following the *DWH* spill indicated that exposure of *Sargassum* to dispersants increased its tendency to sink (Powers et al., 2013), the seaweed is an abundant, naturally ephemeral habitat; therefore, reducing potential exposure of wildlife to oil through response mitigation may well represent a reasonable tradeoff against the loss of habitat and associated communities. The value of threat removal is increased when combined with reconnaissance and intervention to remove oiled animals in advance of potentially injurious response actions. However, efforts targeting individual animals may reach only a fraction of animals, especially in larger spills.

Figure 4.14. Aerial dispersant application from a Basler BT-67 fixed wing aircraft targeting emulsified oil in a convergence line during the Deepwater Horizon *spill, May 2010. Photo: Petty Officer 3rd Class Stephen Lehmann, U.S. Coast Guard.*

Overview of Shoreline Cleanup Methods

Shoreline oiling occurs when oil that has not been recovered or treated on the water reaches the beach or coastline, usually driven by onshore winds and/or falling tide. It is an important and generally labor-intensive target for land-based cleanup operations. Figure 4.15 shows typical shoreline response approaches (note that techniques such as flushing and burning would be unlikely to be considered in areas utilized by sea turtles). For more complete discussion of shoreline response, the reader is directed to focused discussions of shoreline response strategies and methods such as those of ITOPF (see https://www.itopf.org/knowledge-resources/documents-guides/response-techniques/shoreline-clean-up-and-response/) and NOAA (https://response.restoration.noaa.gov/sites/default/files/jobaid_shore_assess_aug2007.pdf).

Oiling of sand beaches, in particular, is a highly visible consequence of some oil spills that often draws significant public attention and concern. In addition to their economic importance for tourism, these shorelines are key habitats for many different types of wildlife and sensitive vegetation. Sea turtles nest on sand beaches in many areas within the U.S. and its territories. Oil stranded on shorelines presents the greatest risk to sea turtles when a spill occurs during periods of active nesting and hatching, which is most intensive during summer months. As with open-water remediation, shoreline cleanup can benefit sea turtles by removing oil from the nesting environment, but also has unintended impacts. It is important for responders and planners to be aware of shoreline risks posed to sea turtles, and measures that are necessary to minimize or prevent further damages.

Figure 4.15. Primary response approaches for shorelines. Graphic by NOAA.

During a spill response, once the oil has come ashore on a beach, the occurrence and the extent or severity of oiling on the shoreline is documented using the Shoreline Cleanup Assessment Technique (SCAT). SCAT training classes occur on a frequent basis around the country, and important components of these classes are the practical sessions conducted in the field. In the absence of actual oil on the beaches, instructors often use seaweed and other debris ("wrack") pushed by the wind and stranded by the falling tide as surrogates for oil on the shorelines. In training classes that occur during nesting season, the marked locations for sea turtle nests and the distribution of surface wrack illustrate the potential for shoreline impacts to nests from stranded oil (Figure 4.16a & b).

Depending on the specific situation and the time of year relative to nesting and hatching, many of the usual and accustomed shoreline cleanup methods appropriate for sand beaches may be employed, but with additional caution and awareness (i.e., the overlapping "sweet spot" in the Venn diagram of Figure 4.2). The federal agency responsible for shoreline response must consult with the USFWS as part of the ESA Section 7 process. Measures to avoid and minimize the impacts to sea turtles (nesting females, nests, hatchlings) from beach cleaning operations must be incorporated. In addition, states have sea turtle protection laws and regulations that must be followed as well. The primary threats to sea turtles posed by cleanup operations are similar to those from a beachgoing public, but at a much larger scale with increased potential to inflict greater harm by virtue of large groups of people with tools and heavy equipment

Figure 4.16a & b. Sea turtle nest in Bahia Honda State Park, Florida observed during a Shoreline Cleanup Assessment Technique (SCAT) training class. The stakes and yellow flagging mark a sea turtle nest above the high tide line. As shown by the beach wrack used as a surrogate for oil, beachcast oil is washed close to nests and creates a zone of contamination between the nesting areas and the sea, placing nesting females, eggs, and hatchlings at risk. Source: NOAA.

The probability that sea turtles will encounter either shoreline oiling or shoreline cleanup activities, particularly during nesting, has a seasonal component to it. However, species and geographical differences make broad generalizations difficult. A set of summary tables produced for the NOAA oil spill guidelines for sea turtles (NOAA, 2019) provide a more regionally nuanced reference for understanding the risk of encountering sea turtles during a specific time of the year; those tables are included here as Appendix D.

Shoreline Cleanup Assessment Technique (SCAT) Surveys

Surveys by SCAT teams were introduced earlier in this chapter. SCAT is an integral part of most oil spill responses, and represents the "eyes" of the Incident Command on conditions in the field. SCAT teams determine the extent and the severity of shoreline oiling, and guide the actual remediation of oil by the Operations Branch of the Unified Command. The actual SCAT teams consist of representatives from the Responsible Party, federal agencies, state agencies, tribal representatives where appropriate, landowners, and other members as needed (e.g., resource advisors for sensitive areas or wildlife reserves, archaeologists where cultural resources are present).

Sand beaches used by sea turtles for nesting can present challenges for SCAT surveys by way of their complex dynamics. The coastal physical processes responsible for creating and maintaining the familiar characteristics of sand beaches frequently result in oil deposited on the beach being buried by subsequent cycles of beach building. For SCAT personnel who are marking aggregations of oil to be addressed by cleanup workers, this means surveying for oil buried in the sand. This is usually accomplished with a shovel. Excavating pits or trenches to locate buried oil is a standard SCAT protocol on depositional beaches, especially sand. This is an obviously labor-intensive activity. In the case of the *DWH* spill, where thousands of pits were necessary, the task was mechanized by equipping a Bobcat-type excavator with a drilling attachment (Figure 4.17).

As with other modifications of nesting beaches, excavations inherent in the SCAT process could be a potential source of disturbance to either nesting females or emergent hatchlings. However, a standard procedure for SCAT excavations is to "replace your divot," to use a golfing term—in other words, fill in any pits or trenches after assessment for buried oil. Adherence to this practice will reduce the possibility that pits would become obstructions or literal pitfalls for sea turtles.

An additional potential issue here is that of undetected nests: Even with regular nesting surveys, there are missed nests (estimated at 8%). There is a potential that this type of reconnaissance excavation during SCAT could uncover a missed nest and uncover a nest or break the eggs. In those events, the SCAT Team would necessarily report the occurrence to the Wildlife Unit and the DOI representative in the Unified Command.

While the most important components of the SCAT process are observational on the part of the field team, the teams survey the entire beach face and may encounter sea turtle nests in the upper portion of the shoreline. Like other personnel working on the beaches, SCAT teams should be briefed on appropriate practices near nests. In addition, because SCAT teams survey large sections of the potentially affected shorelines in a spill zone, they may encounter stranded animals on the shoreline and can be a useful source of field reconnaissance for wildlife operations. Contacts for wildlife specialists and agencies should be carried by SCAT team leaders in the field.

Figure 4.17. Mechanized excavation of a sand beach for SCAT during the Deepwater Horizon *spill to survey for buried oil. Source: NOAA.*

Manual and Mechanical Oil Removal

Manual and mechanical beach remediation methods are generally the simplest and most common techniques used in all shoreline cleanups, and range from picking up tarballs and other oil residues by hand to use of heavier mechanized equipment. Both manual and mechanical removal methods work well on sand beaches, and both have been used at turtle nesting sites. From the resource perspective, manual removal is preferred because it requires less heavy equipment and tends to remove less sand (Figure 4.18). Sand removal should be minimized as much as possible on turtle nesting beaches, and beach profiles should not be altered because female turtles coming ashore to dig nests could become disoriented. However, if oiling is extensive and subsurface oiling is present, mechanical methods can be used with some precautions and careful oversight. A combination of mechanical and manual removal methods was used in spills in Puerto Rico, Tampa Bay, and the Gulf Mexico (Chapter 5). During the *DWH* spill, beach cleanup activities in the Florida Panhandle ultimately deterred nesting females, as evidence by lower loggerhead sea turtle nest densities compared to previous years and unaffected beaches (DWH Natural Resource Damage Assessment Trustees, 2016; Lauritsen et al., 2017).

Figure 4.18. Manual removal of residual oil during the Deepwater Horizon *spill in the Bon Secour National Wildlife Refuge, Alabama. Mechanical equipment was permitted for logistical support and to transport the manually recovered oil. Photo: NOAA.*

Turtle nests should not be disturbed during cleanup activities. Personnel that monitor beaches for sea turtle nests typically mark nests using flags, fencing, and other materials (see Figures 4.19). Such marking is especially important for areas under threat from spills as it allows response workers to avoid disturbing or damaging nests. In general, daily early morning nesting surveys by authorized personnel should be completed prior to any response workers or heavy equipment being allowed on the beach to ensure that nests are marked before telltale sea turtle tracks (crawls) of obscured. Even foot traffic over nests, which are >50 cm (~2 feet) deep, compacts the sand and makes it difficult for hatchlings to emerge. Equipment and personnel also can crush eggs in nests

Figure 4.19. A sea turtle nest at risk the 1993 Bouchard B155 *oil spill in Tampa Bay. The trench and adsorbent snare boom (black material on the ocean-facing side of the nest) were intended to reduce the severity of exposure from any oil stranding near the nests. This approach requires consistent monitoring of the nest because hatchlings will be unable to reach the water. Photo courtesy of Dr. Anne Meylan, Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute.*

and compact sand to the degree that females have a difficult time digging their nests. Vibrations from heavy machinery may result in hatchlings emerging from their nests during the day, which leaves them more vulnerable to predators. Restriction of response vehicles and heavier equipment to the middle and lower intertidal levels, well away from nesting sites, helps to reduce these effects.

If cleanup activities are conducted at night, the artificial lighting required can deter nesting females and disorient females and hatchlings from finding the sea. Any artificial lighting associated with the response should be minimized during the nesting season. Even the use of flashlights can cause problems and should be avoided if possible or only emit long wavelength light source (>560 nm). As previously noted, extensive, detailed information and guidance on lighting considerations that affect sea turtle behavior are available and must be incorporated into plans for night activities associated with spill response. Activities should cease at specified times in the evening to avoid deterring females or causing disorientation during spill responses coinciding with sea turtle nesting season. Best Management Practices may include such measures as staying 50 feet away if a nesting female or hatchlings are observed.

Disposing of oiled sand is an important, and often overlooked, aspect of manual or mechanical removal, because it involves transporting potentially large quantities of material to treatment or disposal sites. Offsite treatment and subsequent replacement is an alternative that can be considered, especially where sand volume is not naturally maintained on beaches (many recreational beaches are artificially maintained and augmented with additional sand transported from outside sources). At the *Morris J. Berman* barge spill in Puerto Rico, oiled sand was treated off-site; however, the excavated sand was not redeposited on the beach. Instead, it was used for construction projects.

Figure 4.20. "Operation Deep Clean" excavation activity near Gulf Shores, Alabama, January 8, 2011. Photo: NOAA.

During the *DWH* response, large volumes of sand were excavated from recreational beaches in Mississippi and Alabama and processed through industrial sifting machines to remove tarballs that had washed ashore (Figures 4.20, 4.21). This kind of operation required large pieces of earthmoving equipment and transport to the sifters, followed by transportation back to replace the sifted material back on the beach, where it was graded back into the natural beach profile.

Figure 4.21. Power Screen bulk sieving operation in Gulf Shores, Alabama, January 8, 2011. Photo: NOAA.

Vacuuming

While vacuuming would not be considered for use on nesting beaches, it is mentioned here because it might be a viable cleanup option in mangrove habitat or bedrock platform areas that are considered to be sea turtle habitat, such as green sea turtle haulout areas along the coast of Hawaii. Vacuuming can remove pooled oil or thick oil accumulations from solid or hard-packed shoreline surfaces, and depressions such as tidepools, and channels (Figure 4.22). The equipment that can be employed ranges from small units to large suction devices mounted on dredges or trucks. Vacuuming can be used effectively on heavier and medium oils, provided they are still reasonably fluid. Lighter, more flammable refined products, such as jet fuel and diesel, generally are not vacuumed because of the hazard from fire and explosion. These lighter oils also tend to evaporate relatively rapidly and typically do not persist as liquids on the water or on shoreline substrate.

Figure 4.22. Vacuuming oil at the edge of a mangrove stand during the 1993 Tampa Bay barge spill. Photo: Jeff Dahlin, Research Planning Inc.

The potential bulk removal of oil using vacuuming offers some advantages; however, the attendant equipment and personnel necessary for the staging and use of the technique could still affect sea turtles through damage to habitat or general disturbance. Like many of the response methods we might consider for use in a given incident, there exists a narrow set of conditions and circumstances within which we would consider vacuuming techniques to be appropriate. If the incident occurs in an area where sea turtles may be encountered, discussions about the use and operational implementation of vacuuming should necessarily include wildlife managers and regulators to ensure that safeguards and best management practices are enacted and followed.

Passive Methods

Passive response techniques rely on some mechanism to collect and hold oil until workers can remove it for disposal. The most common methods involve the deployment of absorbents and adsorbent booms and pads, which typically utilize materials to which oil is known to adhere, such as polyethylene, configured in such a way as to maximize the surface area. Ideally, the sorbent material is hydrophobic (water-repelling) and oleophilic (oil-attracting). Common examples of passive sorbents are snare boom and "pom-poms" (so-called because they resemble the cheerleading accessory) (Figure 4.23).

Figure 4.23. Adsorbent "snare" boom, or "pom-poms," deployed on a beach at Fourchon Beach, LA, during the Deepwater Horizon *spill. Photo: NOAA.*

Artificial barriers, such as berms, have been constructed, ostensibly as a passive means to prevent/reduce shoreline oiling. During the *DWH* spill, a large-scale project was launched by the State of Louisiana to build a series of berms near the Chandeleur Islands. The original proposal was for over 100 miles of sand berms to be constructed using dredge machinery. Ultimately, only 10 miles of berms were built at an estimated cost of $360 million and were completed after oil had already come ashore. The berms were successful in capturing only 1,000 bbl of oil by late October, 2010, three months after the leaking wellhead was sealed (Rudolf, 2010). Moreover, federal Trustees documented six sea turtle deaths during the construction activities and estimated many others were killed during this and other response activities (DWH Natural Resource Damage Assessment Trustees, 2016).

Use of barriers on shorelines during nesting or hatchling emergence periods can affect large numbers of turtles by either preventing females from reaching nesting beaches, or blocking the movement of hatchlings or adults into the water. For hatchlings, temporary entrapment by barriers can increase the risk of predation during their migration to the water, when they are especially vulnerable (Chapter 2). Barriers also can cause hatchlings and nesting females to become disoriented, dehydrated, or otherwise expend vital energy reserves, which can be lethal. In addition, booms, which are designed to protect resources on one side of the deployment, can potentially increase turtle exposure to oil on the other side, whether the animals are entrapped or not. Therefore, use of these methods in areas of sea turtle nesting requires careful consideration and consultation with resource managers. In most instances, deployment likely is contraindicated when females are nesting. Use during periods of hatchling emergence requires rigorous mitigation through regular monitoring of nests and assurance of clear egress to the sea.

Bioremediation

Bioremediation—specifically adding nutrients to an oil-impacted area—can enhance oil degradation in many habitats, including sand beaches (Venosa et al., 1996). It is generally considered to be a "finishing" technique, to be applied after bulk oiling has been reduced by other means. The microbial degradation of petroleum hydrocarbons is not considered to be a rapid process, occurring over times frames of at best, days to weeks. However, its use requires all of the aforementioned considerations and invokes the same constraints as those related to mechanical removal. The effects of nutrient enrichment on sea turtle nests and egg development have not been studied, but could include alteration of the physical characteristics of the nest substrate and microbiota. Thus, it is prudent to avoid use on or around known sea turtle nests until effects of bioremediation on nesting substrate and developing eggs are understood.

Another indirect method of bioremediation that is a definite concern from a sea turtle management perspective is tilling, in which the beach surface is worked with equipment to expose and aerate oil residues. Although tilling is frequently used on recreational beaches (it resembles the grooming practices common in such areas), it is not recommended on active nesting beaches because of its physical disruption and requirement for heavy equipment.

Anticipating the Consequences of Response

While the primary objective for any spill response method is to reduce the harm imposed on the environment by the presence of oil, we have seen that there are costs associated with their implementation. Much of the scientific support and response guidance that is provided before and during spill incidents is invested in evaluating tradeoffs associated with different methods. In recent years, there has been renewed interest in more formal processes of tradeoff analysis, such as Net Environmental Benefits Analysis (NEBA), Spill Impact Mitigation Analysis (SIMA), and Consensus Ecological Risk Assessment (CERA). In practice, decision-making entities like the Environmental Unit within the Incident Command System, or Regional Response Teams established under the Oil Pollution Act, exist to determine both explicit and implicit tradeoffs associated with response strategies.

The response methods we have described in this chapter are mostly those that have been developed and used at multiple spills. The use of dispersants and *in-situ* burning during the *DWH* spill was unprecedented and exceptional, but the circumstances of that spill were themselves unprecedented and exceptional. In the broader context, dispersants and on-water burning have been employed sparingly over the more than 50-year history of U.S. spill responses: dispersants being used 27 times, and *in-situ* burning, just twice. New and improved techniques continue to be developed and refined. While innovation is important for improving response capabilities, these new approaches also require thoughtful consideration of the near-term and future consequences for wildlife and the environment.

Direct intervention for oiled sea turtles and nests

The previous sections of this chapter reviewed the actions that can be undertaken during oil spills aimed at removing oil from the environment or moderating the harm it imposes on resources of concern. These response methods may reduce the risk of exposure to sea turtles, but also have their own consequences. Given the protected status of sea turtles in the U.S., federal and state agencies have a responsibility to implement response measures to minimize the harm to sea turtles while conceding that harm from oil is likely to have already occurred. These measures may include direct intervention on nesting beaches, in the water, or both, depending on the timing and location of the spill.

Spill-related sea turtle reconnaissance activities

Oil spills within areas inhabited by sea turtles generally warrant surveys by vessels and/or aircraft, depending the nature of the incident, in order to help ascertain risks to wildlife and inform response measures (Figure 4.24). Moreover, such surveys are valuable for Natural Resource Damage Assessment as well as spill response. Both aerial and vessel surveys may be required depending on the time and location of a spill. For example, while aerial surveys can cover large areas and are useful for sighting some animals, small sea turtles under 45 cm in length, such as those found offshore, are not visible from manned aircraft. Multi-purpose wildlife surveys are often used during

Figure 4.24. Dedicated mammal/turtle overflight photo from the Deepwater Horizon *spill showing loggerhead turtle and fish (likely cobia) in oil slick. Photo: NOAA.*

spills to maximize resources; however, objectives, survey plans, and observer training must be critically evaluated to ensure that information needs are met.

Figure 4.25. Sea turtle vessel reconnaissance along a convergence zone in the Gulf of Mexico during the Deepwater Horizon *oil spill in 2010. Photo: Blair Witherington, Florida Fish and Wildlife Conservation Commission.*

Vessel-based rescues and stranding response

Oil spills that contaminate offshore waters pose acute risks to hatchling and juvenile sea turtles that rely on surface habitat prone to accumulating oil. Such situations could have significantly harmful consequences for large numbers of turtles, as demonstrated during the *DWH* spill. Because these small turtles are typically at or near the surface and predictably within convergence areas, they can be rescued from spill areas (Figured 4.25). During the *DWH* spill, researchers rescued over 300 juveniles of four species from surface habitats throughout the northern Gulf of Mexico. In addition to providing science-based compassionate care to oiled wildlife, these operations also yielded valuable physical evidence and information that was used to determine the magnitude of sea turtle losses caused by the spill for the purposes of the NRDA process. Similar to aerial surveys, the logistics required to conduct sea turtle rescues offshore are substantial and require experienced personnel, suitable vessels, and close coordination with personnel and facilities that ultimately provide care and treatment of rescued turtles. These efforts represented a humane contribution to the *DWH* wildlife response and provided valuable information for NRDA, but the scale of the rescue operations was minute due a host of logistical challenges and ultimately aided a tiny fraction of the estimated many thousands of sea turtles killed by the spill. The limitations of direct intervention, particularly for ocean-going animals and larger spills, highlights the importance of spill prevention, early detection, and immediate action.

Rescue or relocation of sea turtles closer to shore and larger turtles pose additional challenges. These turtles spend less time at the surface, tend to be relatively dispersed, and many of the capture methods used for research purposes cannot be applied in oil areas due to human safety concerns. In addition, capacity for holding larger turtles in captivity is more limited, and in many instances, turtles tend to return to where they were originally found, which is a significant challenge in terms of effective relocation or deterrence from an oiled area. Therefore, interventions involving larger turtles tend to focus on debilitated animals that require immediate care.

Stranding of oiled sea turtles is another opportunity for direct intervention. The distance of a spill from shore and prevailing winds and currents determine the likelihood that sea turtles affected by a spill will be found as beachcast strandings. For example, few if any stranded oiled turtles may be found during offshore spills because the animals are unlikely to come ashore unless driven by onshore winds. In general, strandings tend to be most representative of turtles that die or become injured or impaired within a few miles of shore. In addition, the potential chronic effects of oil, which are poorly understood in sea turtles, are more difficult to recognize in stranded animals relative to the more obvious acute consequences of oiling related to initial physical fouling and other direct effects of heavier exposures.

Veterinary care and rehabilitation

The various means of live turtle intervention ultimately require decontamination and veterinary care rendered by qualified personnel. In the U.S., these efforts typically are undertaken by authorized sea turtle rehabilitation facilities (Figure 4.26). Treatment of oiled sea turtles will depend on the properties of various forms of petroleum and its anticipated effects on sea turtles. For crude oil exposure, treatment primarily consists of removal of oil using mild detergent applied to the skin and edible emulsifying agents or oils, such as mayonnaise, vegetable oil, or fish oil, to clean oil from the eyes and mouth. If oil ingestion is suspected, fish oil (alone or mixed with mayonnaise) has been administered by gavage tube to help remove oil from the esophagus and promote defecation. Treatment of dehydration and electrolyte abnormalities using fluid therapy also may be indicated, as well as treatments for other specific conditions. Many oiled sea turtles ingest oil and may pass oil in their feces for weeks, which requires consideration of wastewater disposal.

Figure 4.26. Veterinary care being administered at the Audubon Nature Institute, New Orleans, to a Kemp's ridley turtle recovered during the Deepwater Horizon *spill. Photo: NOAA.*

Survival of oiled sea turtles with veterinary care is, fortunately, high based on data from previous spills. For example, of the hundreds of oiled turtles rescued during the *DWH* spill, almost all survived and no deaths were attributed to oiling. However, such outcomes are not representative of the fate of oiled animals that do not benefit from such care. The veterinary assessments and observations made during care and treatment of oiled turtles during the *DWH* response have significantly contributed to our understanding of oil effects on sea turtles and helped inform the NRDA. This example highlights the importance not just of mounting robust efforts to rescue sea turtles from oil, but also planning and executing these efforts to collect important data for assessing the overall effects of spills on turtles.

Nesting beaches

Response operations involving nesting beaches can be especially challenging because large numbers of sea turtles may be affected and the nesting process and nest incubation are sensitive to many types of disturbance. Planning and execution of response measures on nesting beaches must be dynamic, efficient, and consider the current status of nesting as well as events anticipated to occur within the span of response operations. If a spill occurs prior to nesting season, every effort should be made to complete cleanup operations prior to females coming ashore.

Once nesting commences, response priorities are to protect sea turtles and their nests during cleanup (as we have previously discussed in this chapter), minimize ongoing disruption to the degree possible, and attempt to remove oil from beaches and nearshore areas before eggs hatch and hatchlings head to sea. If sea turtle nests become oiled, special protocols are followed by authorized wildlife responders to safely remove the material or determine the best alternative course of action. In addition to protection of eggs *in situ*, consistent monitoring may be necessary to ensure that hatchlings have unimpeded access to the water.

Excavation and relocation of sea turtle eggs is a measure of last resort and is only undertaken when *in-situ* protection will not effectively reduce the risk to emerging hatchlings or the risk is unavoidable and dire. There are a number of critical considerations in terms of the logistics of successful relocation. Nests must be relocated within 12 hours of being laid, otherwise the embryo is likely to die as a result of the manipulation. The eggs must be handled gently and any unnecessary movement (especially rotation) avoided. If relocation is adopted as an option during a spill, only trained, experienced, and authorized personnel may excavate the nests or move eggs. Hatchlings should be released within a safe area that allows them to become part of their native population or management unit whenever possible.

The *DWH* oil spill provides a large-scale case study on the complexity of oil spill response in the face of active nesting beaches under threat. Because the release was uncontrolled and continued over the course of months, the potential for oil to impact both sea turtle nests and emergent hatchlings became a major concern for state and federal trustees. As a result, trustees began discussing relocation/translocation of known nests from the spill-affected area to one considered to be low risk for oil. The risk assessment involved the consideration of many factors, including the comparison of oil occurrence vs. known nesting locations.

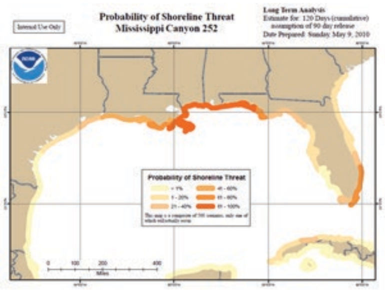


Figure 4.27. NOAA TAP model run for the Deepwater Horizon *spill. Source: NOAA.*

Another consideration was a forecast of where the oil might strand in the Gulf of Mexico based on oceanographic conditions and weather patterns. NOAA responders have used a probabilistic oil trajectory model, the Trajectory Analysis Planner (TAP) to identify shorelines at greatest risk of oiling based on a given source location and regional currents and weather. TAP runs the General NOAA Operational Modeling Environment (GNOME) model 500 times with different current and weather scenarios to yield a probability analysis of where oil is likely to impact the shoreline. A TAP analysis for the *DWH* spill and the Gulf of Mexico (Figure 4.27) was created in the early weeks of the spill, and this was provided to federal sea turtle managers to be included in their deliberations.

Ultimately, to prevent hatchlings from emerging from northern Gulf nests and entering oil-filled northern Gulf waters, and to avoid their risk of being killed by beach response activities, 274 sea turtle nests and 28,681 eggs were excavated (Figure 4.28) and translocated to the Atlantic coast of Florida, near the Kennedy Space Center. Although the proportion of eggs that hatched was similar to that of natural nests and indicated that relocation was successful in terms of egg viability, for the purposes of damage assessment, these hatchlings were considered lost to the Gulf ecosystem because it is unknown whether they will return to the Gulf of Mexico (DWH Natural Resource Damage Assessment Trustees, 2016; Provancha & Mukherjee 2011). The great degree of uncertainty related to the fate of the translocated turtle hatchlings underscores the challenging decision-making associated with this kind of drastic intervention during an oil spill or other imminent catastrophe.

Figure 4.28. U.S. Park Service and U.S. Fish and Wildlife Service personnel excavate a sea turtle nest in Bon Secour National Wildlife Refuge, Alabama, during the Deepwater Horizon *spill. Eggs were transported to the Atlantic coast of Florida where they were incubated, hatched, and released. Photo: Bonnie Strawser, USFWS.*

In terms of intervention, oiling of nesting females presents a dilemma for wildlife managers. Female turtles of most species nest at night and are thus not always observed. Although oil may be cleaned from females in the field after nesting so as not to disrupt the process, further intervention, e.g., transport for evaluation at a rehabilitation facility, is not recommended and should not be attempted unless sea turtles are unable to return to the sea. The rationale for this approach is that females nest multiple times during a season, and disruption of this cycle through active intervention has negative consequences.

Much of what we now know about oil spill response in sea turtle habitat derives from the *DWH* experience. Prior to that incident, impacts to sea turtles during oil spills were infrequent, poorly documented, or both. Like nearly everything else about the *DWH* spill, its effects on sea turtles were unprecedented. It can be argued that the circumstances of the spill in the Gulf of Mexico were so unlikely and virtually unique that we should not rely solely on this one spill to define the new reality of how we deal with oil and sea turtles. However, in this case, the scale of the incident and the ensuing response related to sea turtles provided a tremendous amount of experience and information, both scientific and operational, that can only benefit future responses.

Table 4.1. Summary of egg translocation and hatchling release effort to prevent Gulf of Mexico hatchlings from being exposed to Deepwater Horizon *oil and response activities. Source:* Deepwater Horizon *Natural Resource Damage Assessment Trustees, 2016; Provancha & Mukherjee 2011).*

	Clutches	Egg Count	Hatchlings Released
Kemp's ridley	5	483	125
Loggerhead	265	27,618	14,216
Green	4	580	455
Totals	274	28,681	14,796

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Chapter 5. Oil Spill Trends and Case Histories of Incidents Affecting Sea Turtles

Debra Simecek-Beatty

Key Points

- Despite the potential for oil spills to harm sea turtles, and the global distribution of spill incidents in areas where sea turtles occur, oil spill impacts on sea turtles have rarely been documented. The infrequent nature of such documentation is likely due to the low probability of observing and recovering oiled turtles and to the lack of efforts dedicated specifically to documenting sea turtles in and rescuing them from oil.
- In U.S. waters, sea turtles have been assumed or documented to be at risk of exposure in many oil spills, particularly in the Caribbean and Gulf of Mexico. The clearest example was the 2010 *Deepwater Horizon (DWH)* spill; the magnitude of

sea turtle mortality caused by DWH was unprecedented relative to any previous oil spill anywhere in the world.

- Although spills where effects on sea turtles have been well-documented are predominantly larger crude oil spills, fuel oils spilled from grounded fishing vessels or cargo ships is a much more frequent occurrence. Such spills should be included in future planning and drills.

Spills that Threaten Sea Turtles

Planning response and assessment activities for spills that threaten sea turtles may be improved by understanding past spills and responses to them. How many incidents have occurred that threatened sea turtles? Is there a pattern to the occurrences or severity of spills? Can we predict the effects on sea turtles? How many turtles were exposed, threatened, or affected? Did the response consider potential injury to sea turtles during planning and implementation? Even when basic information about sea turtles is available for a given spill, the existing records do not necessarily convey the extent of concerns and impacts that may have occurred. We now know that detection of oil effects on sea turtles and their habitats requires explicit focus of response or assessment efforts. Unfortunately, reports of sea turtle effects frequently consist of limited, shore-based, and opportunistic observations. The absence of systematic data collection challenges the production of scientifically robust documentation of spill effects on sea turtles which can stymie subsequent mitigation or restoration efforts.

The authors of this document, which focuses on the waters of the U.S., recently collaborated with other colleagues worldwide to publish a journal article (Wallace et al., 2020) that provides an international perspective and a synthesis of information about oil and sea turtles. That article is a useful companion piece to the current chapter. Wallace et al. performed a global review to evaluate reported effects of oil spills on sea turtles, with the goals to (1) summarize available information about oil spills and their effects on sea turtles; (2) identify major knowledge gaps; and (3) provide recommendations related to oil spills and sea turtles for managers, researchers, and conservation groups around the world. Wallace et al. (2020) reviewed over 2,000 spill incidents that occurring within the past 60 years and found that effects of oil spills on sea turtles were reported in less than 2% of incidents. Most of those reported effects were related to heavy external oiling, while chemical effects of oil exposure were not well-defined.

Accounts of oil spill effects on sea turtles within published incident and spill response reports often focus on immediate or short-term effects, particularly fouling, mortality, and impacts on nesting beaches. Available resources seldom address potential sublethal and chronic effects or results of any subsequent monitoring. Over the history of oil spills worldwide, longer-term monitoring and chronic effects studies, if pursued, have mostly taken place outside the realm of response itself, under the auspices of academic researchers or others independent of the response structures. Further compounding the paucity of studies of persistent, delayed, or chronic effects of spills are the inherent difficulties in studying long-lived, ocean-going, protected species. The consequences of these factors are that we understand far less about long-term or sublethal impacts of oil and oil spill response than we do about mortalities and short-term effects.

For the current effort, we reviewed the source, size and frequency of all previous oil spills that occurred within tropical (between 23.5°N and S) and subtropical (between 40°N and S) zones, the predominant range of sea turtles (Chapter 1). Three key sources of spill data and information were used: the NOAA Historical Incidents Database (https://data.noaa.gov/dataset/noaas-office-of-response-and-restoration-historical-oil-and-chemical-spill-incidents-database); the NOAA 1967-1991 Oil Spill Case Histories document (https://response.restoration.noaa.gov/sites/default/files/Oil_Spill_Case_Histories.pdf); and the French Centre of Documentation, Research, and Experimentation on Accidental Water Pollution (CEDRE) database (http://wwz.cedre.fr/en/Our-resources/Spills). Other sources included databases maintained by other organizations, such as the International Tanker Owners Pollution Federation, Limited (ITOPF) (http://www.itopf.com/knowledge-resources/data-statistics/statistics/), which includes global spill incidents involving tanker vessels.

Sea turtles rarely range outside the 40°N and S latitude subtropical band.[1] Using the boundaries of 40°N and 40°S, the three primary sources we used to define a subset of oil spills that represented potential risks to sea turtles totaled 1,432 since 1957. Far fewer spills, 191, occurred in tropical waters where sea turtles would be likeliest to frequent. Finally, only 22 incident summaries over the years articulated some sort of impact to sea turtles, either at sea or on nesting beaches. Figure 5.1 contrasts totals and trends in oil spills (volumes and numbers) against total numbers of incidents involving sea turtles. Graphic portrayal of the occurrences of spills by latitude (Figure 5.2) does not reveal particularly compelling trend information, except for perhaps reflecting the influence of increased petroleum-related activities and spill incidents in the northern hemisphere. However, in both figures, the numbers of spills reported to have affected or involved sea turtles (plotted as black bars) represent a very small proportion of overall events. The dearth of sea turtle oil effects reporting could be due to turtles rarely being impacted by oil spills—but it seems more likely an artifact of turtles not being an explicit focus of response or assessment efforts, thus limiting their resultant documentation.

All told, around 100 historical accounts mention sea turtles or identify turtles as being at risk. Not all of the incidents actually resulted in oil being released. Within the

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1 Rarely, but not unheard of: the Alaska Department of Fish and Game published a fact sheet on sea turtles (Hodge & Rabe, 2008) in recognition of the fact that state records showed 19 reports of leatherbacks, 15 greens, 3 olive ridleys, and 2 loggerheads in Alaskan waters.

Figure 5.1. Number and estimated volume of reported oil spills worldwide from 1940-2017. Numbers above white columns note the number of spills. Black bars show the number of spills in which potential effects on sea turtles were noted (total = 22 incidents, max). Source: Wallace et al. (2020).

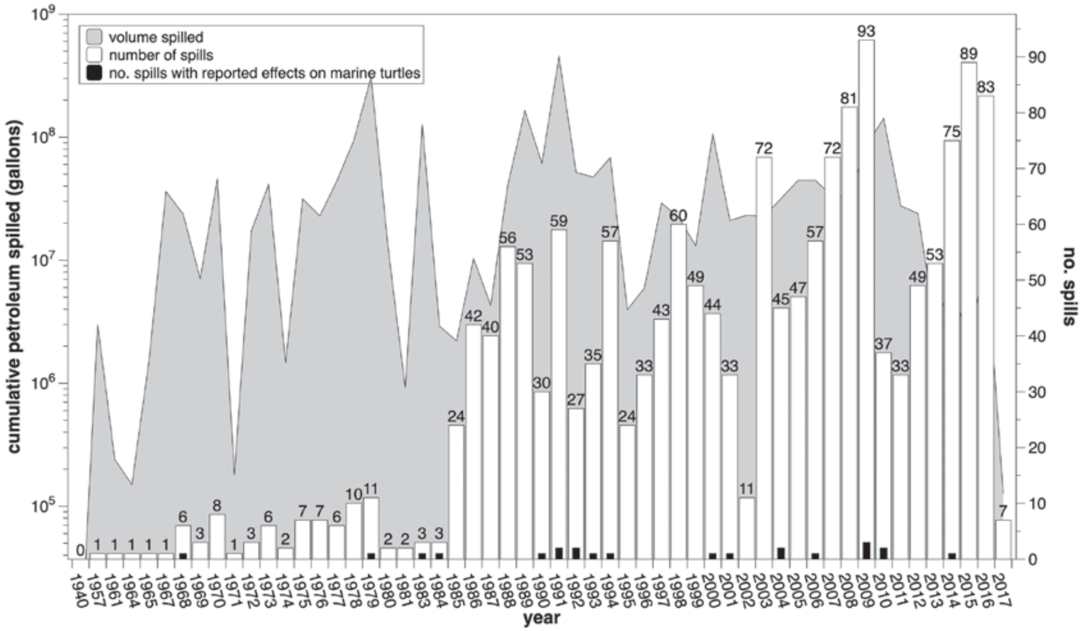
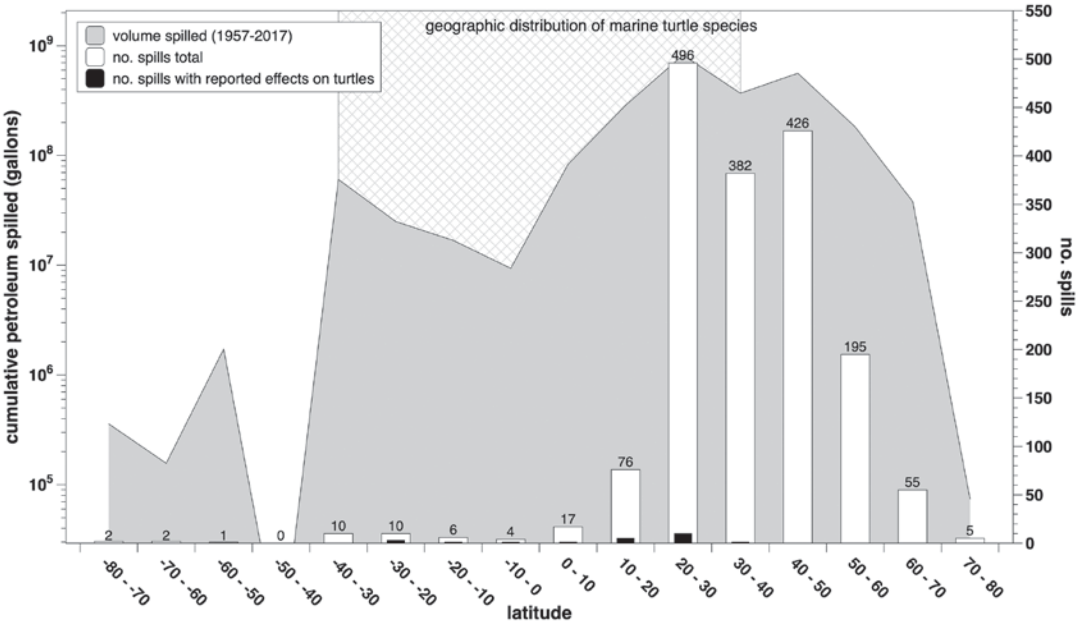


Figure 5.2. Number and estimated volume of reported oil spills shown by latitude from 1957-2017. Numbers above white columns note the total numbers of spills. Black bars show the number of spills in which potential effects on sea turtles were noted. Source: Wallace et al. (2020).



subset of incidents with turtles at risk, oiled/injured/dead sea turtles were reported in 18 cases: the T/V *Witwater*, *Ixtoc I*, Nowruz Field, T/V *Alvenus*, Gulf War, Tarague Beach mystery spill, *Vesta Bella*, St. Eustatius refinery, Tampa Bay multi-vessel collision, *Morris J. Berman*, Fort Lauderdale mystery spill, T/V *Jessica*, Mississippi Block 69 pipeline, M/T *Vicuña*, M/V *Pacific Adventurer*, Montara platform, the *DWH*, and Texas City "Y" spills.

Four of these spills with explicit turtle impacts are among the largest and longest duration marine spills in history, accounting for around 20 million bbl of oil released:

- the 1991 Gulf War spill in Kuwait and Saudi Arabia (6 to 8 million bbl);
- the 1979 *Ixtoc I* platform blowout in Campeche Bay, Gulf of Mexico, Mexico (3.5 million bbl);
- the 2010 *DWH* mobile drilling unit explosion in the northern Gulf of Mexico, U.S. (3 million bbl);
- the 1983 Nowruz platform spills in the Arabian Gulf (1.9 million bbl).

All four of these large spills involved oil production facilities and thus, crude oil. The volumes and durations of these crude oil spills, and the documentation of turtle injury that resulted from the *DWH* incident, might seem to support the notion that crude oil constitutes the greatest risk to sea turtle populations. However, while we know that crude oil is harmful to wildlife, including sea turtles, the large-scale trends in oil spills discussed previously strongly suggest that it is more likely that turtles will be exposed to oil spilled from smaller sources that are more frequent and widespread in occurrence, such as cargo and cruise ships, fuel oil barges, or pipelines, that carry the full range of petroleum products from heavy fuel oil to refined products such as diesel and aviation fuel. The effects of such events on sea turtles have not been documented to the same degree as the higher profile crude oil spills, thus impacts thus impacts were documented poorly, if at all.

Background: Facts, Figures, and Trends in U.S. and Global Oil Spills

Forecasting the probability and nature of future oil spills is challenging due to (among a myriad of influences) changes in energy demand, methods of access and transportation, and implementation and modification of laws and regulations. The occurrence of poorly predictable events, such as extreme weather, accidents, and intentional acts, introduce additional uncertainty in knowing when and where a spill may occur. With the notable exceptions of spills caused by Hurricanes Katrina and Rita in 2005 (190,000 bbl), and the *DWH* spill (5 million bbl), the general trend for oil spills into navigable waters of the U.S. over the last 30 years has been downward, both in terms of numbers of incidents (Figure 5.3) and volumes spilled (Figure 5.4). Although the particularly large spills in the 2000s resulted in significant environmental impacts, it is useful to consider trends outside

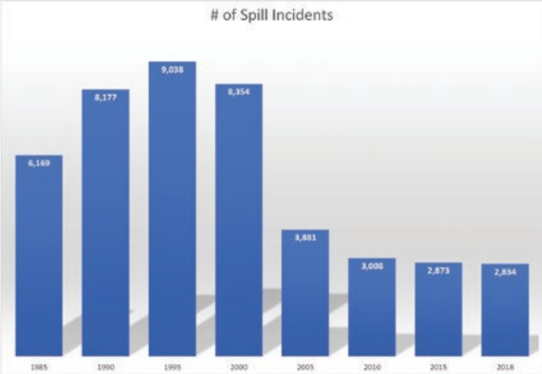


Figure 5.3. (left) Total number of oil spills from vessel, non-vessel (pipeline & production facilities), and mystery sources, by year. Source: U.S. Department of Transportation, Bureau of Transportation Statistics.

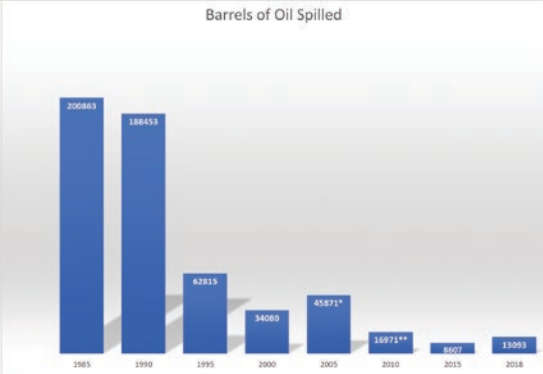


*Figure 5.4. (right) Total volumes of oil spilled from vessel, non-vessel (pipeline & production facilities), and mystery sources, by year; *excludes releases due to Hurricanes Katrina & Rita; **excludes* Deepwater Horizon *spill. Source: U.S. Department of Transportation, Bureau of Transportation Statistics.*

of these large spills, which fortunately are relatively infrequent. Etkin (2010) analyzed U.S. spills of oil from multiple anthropogenic sources (summarized in Figure 5.5) and concluded that spill rates had declined dramatically in the decades following the 1969 Santa Barbara platform accident that represented the first large American oil spill. They attributed the steady decrease to prevention-oriented regulations and voluntary oil industry initiatives. Similarly, the International Tanker Owners Pollution Federation, Ltd. (ITOPF) summary for the years 1970-2016 (Figure 5.6) shows a declining trend for oil tanker spills, expressed as the number of large (>700 metric tons) spills. As noted previously, the ITOPF dataset is global, but its charter and response activities focus primarily on tanker vessels.

As encouraging as the large-scale trends may be, the known and potential effects of oil and response activities on vulnerable natural resources such as sea turtles (Chapters 3 & 4) reinforce the notion that frequencies and sizes of oil spills are not the only determinants of severity and risk. In the case of sea turtles, geography and seasonality also loom

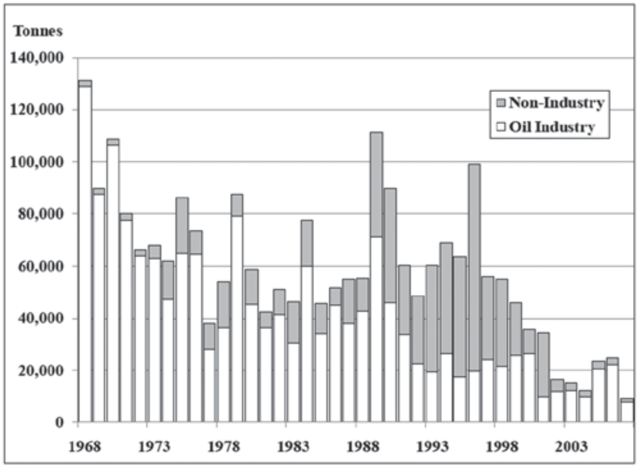


Figure 5.5. Total U.S. oil spills (parsed into oil industry and other sources) into marine and inland waters, 1968-2007. Source: Etkin (2010).

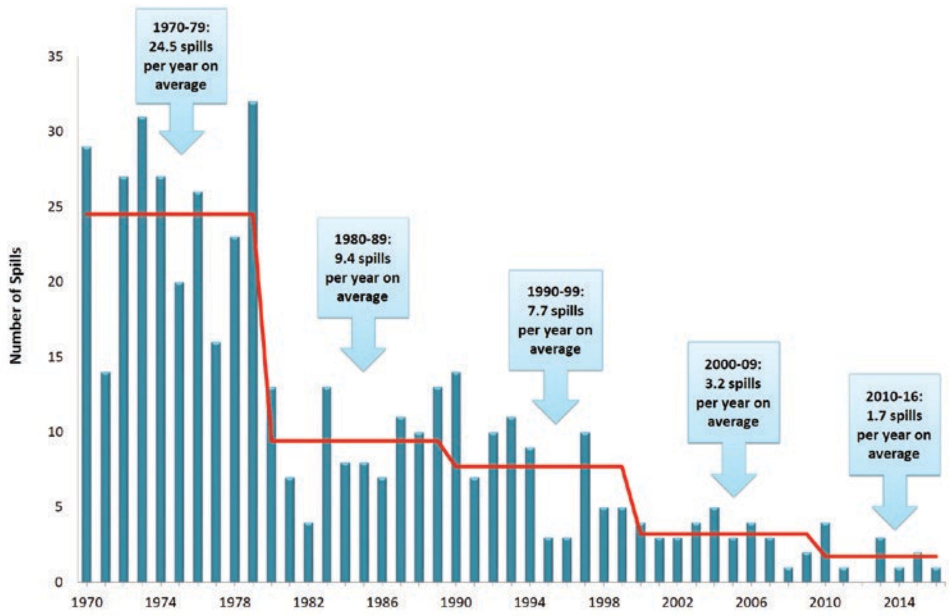


Figure 5.6. 1970-2016 worldwide oil tanker spill trends. Source: International Tanker Owners Pollution Federation, Ltd. (ITOPF).

large as key factors. As demonstrated by the *DWH* spill, large spills or those within key sea turtle habitat during sensitive periods, e.g., peak reproduction season, can be disastrous regardless of their place in an overall trend.

Anyone who has dabbled in the world of financial investments understands the mantra of "Past performance is no guarantee of future results." While it seems both reasonable and popular to link the trend of declining numbers of spills and amounts of oil released with mandated new efforts in prevention and preparedness, and improved regulatory oversight, recent events have shown that these measures can be administratively rolled back quickly and easily. In addition, the push to explore and produce oil from increasingly deeper and more remote portions of the ocean has continued unabated following the *DWH*. Murawski et al. (2020) documented this trend and noted that in 2017, 52% of U.S. oil production originated from ultra-deep (>1,500 m) wells. Mexico, Brazil, and countries in West Africa—that also sustain populations of sea turtles—also are pushing into deeper water.

While we have noted the anomalous and infrequent occurrences of hurricanes such as Katrina and Rita causing releases of oil into the environment, this must be tempered by the growing evidence that climate change is increasing the number and intensity of storm events impacting American shorelines and communities. Oil production and transportation infrastructure is increasingly at risk from climate-driven changes in weather patterns. Sea level rise and increased coastal zone flood risks represent other climate-related threats that may impact oil facilities and alter what have been encouraging downward trends in oil spills.

Case Studies

Although efforts to document sea turtle effects in previous spills have been limited prior to the *DWH* spill, there are some notable examples where exposure and injuries to sea turtles were specifically reported or considered in response efforts. Furthermore, even incomplete, anecdotal records of sea turtle effects during spills serve as reminder that they are among species at risk in much of the world. Past oil spills in which reports or other documentation specifically mention sea turtles to any degree are summarized below. In addition to the description of these events, numbers of turtles, species, and any available information related to size or life stage affected is included. It is important to recognize that the true magnitude of oil effects on sea turtles is not reflected by the reported observations in most instances.

Figure 5.7. Remains of tanker Witwater *off the coast of Panama in early 1969. Photo: Smithsonian Tropical Research Institute.*

Oil Tanker S.S. *Witwater*, 1968

The oil tanker S.S. *Witwater* ruptured in heavy seas off the Atlantic coast of Panama on December 13, 1968, spilling over 14,000 bbl of diesel oil and Bunker C oil into the water approximately two nautical miles northeast of Galeta Island (NOAA 1992). The oil eventually washed ashore onto sand beaches, rocky coasts, and mangroves on Galeta Island. High winds caused a spray of mixed seawater and oil to cover trees and shrubs in the supralittoral zone (area above the high tide line) to a height of two meters above mean tide level. Both red and black mangrove trees were severely oiled, killing most of the red mangrove seedlings as well as the algal community and invertebrate inhabitants of the mangroves (Rutzler and Sterrer 1970). Rutzler and Sterrer (1970) reported dead and dying "small" sea turtles of unspecified species and life stage (green, loggerhead, and hawksbill sea turtles are known to be present in waters along the Panamanian coast) were observed on oiled mangrove beaches two months after the spill; however, the exact cause of death was not determined.

Ixtoc I Well Blowout, 1979

On June 3, 1979, the *Ixtoc I*, an offshore exploratory oil well located 80 km off Ciudad del Carmen, Mexico, suffered a massive blowout of its wellhead when drilling mud circulation was lost, resulting in a fire and the sustained release of crude oil and gas into the Bay of Campeche. An estimated 10,000-30,000 bbl of oil per day were released until two relief wells were drilled and the spill was brought under control on March 23, 1980. The total volume released was estimated to be more than 3.5 million bbl (nearly 150 million gallons). The oil drifted north, eventually impacting portions of the Mexico and Texas coasts. During the interval between the release of oil and its impact on shorelines, weathering significantly altered the oil's original physical and chemical properties and a water-in-oil emulsion, or "mousse", formed.

Figure 5.8. Ixtoc I *well blowout in the Bay of Campeche, Mexico, 1979. Photo: NOAA.*

The spill threatened a primary nesting beach of the Kemp's ridley sea turtle near Rancho Nuevo, Tamaulipas, Mexico. At the time of the spill, thousands of nests had been laid by females. Hatchling emergence begins in mid-June and continues through mid-September. Hatchlings emerge from the nest, enter the Gulf of Mexico, then swim east and north for months, placing them at risk of encountering oil from this spill.

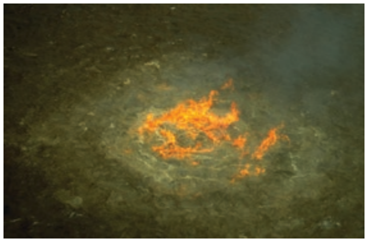


Figure 5.9. Burning oil and gas at the water's surface above the Ixtoc I *wellhead. Photo: NOAA.*

The *Ixtoc I* blowout occurred after nesting but before all hatchlings had left the affected beach. Due to concerns that the young turtles would become oiled onshore or ingest oil in the water, the Mexican Department of Fisheries (MDF) and the U.S. Fish and Wildlife Service (USFWS) planned to airlift approximately 9,000 turtle hatchlings if the oil threatened the nesting beach. By July 23, oil was observed less than 50 km from Rancho Nuevo, so MDF and USFWS moved 9,000 hatchlings to protected lagoons, but by July 27 high seas flowed over islands protecting the lagoons and oil and tarballs began washing onto the nesting beach. The 9,000 hatchlings were held on shore until July 29 then evacuated by helicopter to a patch of *Sargassum* in clean water less than 25 km offshore.

More than 200 gallons (5 bbl) of oil were reportedly recovered during cleanup of the beach and lagoons near Rancho Nuevo, but oil was still evident on the beach during the nesting season the following year. Eventually, oil impacted over 160 miles (256 km) of the south Texas coast, beginning in August and September 1979. By the time the oil reached Texas it was highly weathered and had washed ashore primarily as tarballs, tar mats, or mousse. Environmentally sensitive, economically important beaches in Texas were cleaned daily using rakes and shovels rather than heavy equipment to minimize sand removal. An estimated 10,000 cubic yards (7,646 cubic meters) of oiled material sand was removed along the Texas coast (NOAA, 1992).

Both live and dead oiled sea turtles were observed along the Texas coast after the spill. Six live green turtles and one live Kemp's ridley turtle were collected during the response. Only one, a green turtle, required cleaning and rehabilitation, and was eventually released. In August 1979, five dead juvenile green turtles washed ashore on Padre and Mustang Islands, Texas, all heavily fouled with oil, which may have contributed to their deaths. Two oiled green turtle carcasses and one oiled small Kemp's ridley sea turtle carcass recovered from Laguna Madre, Texas, were shipped to the federal Patuxent

Wildlife Research Center to determine cause of death. The green turtles were described as measuring between 20 to 21 cm in length. Necropsies (Hall et al., 1983) found that while external oil was present on all three turtles, including within the mouth and esophagus, the cause of death could not be determined conclusively. The amount of oil present was considered unlikely to have prevented normal movement or to have been otherwise fatal. Two of the turtles were in poor nutritional condition, but had no apparent specific abnormalities attributed to oil. Chemical analysis found detectable petroleum hydrocarbons in samples of lung, esophagus, intestine, liver, and kidney. It was concluded that oil exposure had been chronic and may have caused the turtles' poor nutritional condition, which in turn led to death, either from oil toxicity or some another undetermined cause.

Despite early concerns about potential long-term impacts of residual oil on nesting beaches affecting orientation cues or hatching success, no persistent effects were attributed to this spill in subsequent years.

Figure 5.10. Heavy residual oiling on Abu Ali Island, Saudi Arabia in 1992 (nine years after the spills from the Nowruz oil field). Oil was chemically linked to the 1983 releases. Photo courtesy of Jacqueline Michel, RPI.

Nowruz Oil Field Spills, 1983

Between January and October 1983, an estimated 1 million bbl of oil were spilled into the Arabian Gulf, primarily from several spills associated with the Iran-Iraq War. On January 24, 1983, a supply ship struck a rig in the Nowruz oil field in Iranian territorial waters, causing a riser rupture and uncontrolled release. The damaged well was not successfully capped until September 18, 1983. At least two other platforms damaged by military action in March 1983 contributed to the spill, as did other potential intentional spills and ballast pumping. Al-Amirah (1985) commented on the difficulty of establishing situational awareness during armed conflicts, and indicated some sources estimated ten wells were spilling 5,000 to 7,000 bbl daily. At least one of the leaking wells was not closed in for two full years.

Large areas of sheen, tarballs, and weathered oil rafts were reported in the Saudi Arabian Gulf during April, May, and early June, 1983. Oil coated rocky shorelines, sand beaches of offshore islands, and the Saudi Arabian mainland. On sand beaches, sand movement during several tidal cycles buried and fragmented the stranded oil. Tarballs were deposited in the intertidal and adjacent subtidal areas of Saudi Arabia, Bahrain, and Qatar.

Between March and mid-April 1983, many dead animals were found along the Saudi Arabian Gulf coast, including over 56 green and hawksbill sea turtles. Because only a portion of the coastline was monitored and strandings represent a small fraction of actual mortality, the number of turtles killed was likely to have been higher. Some accounts indicated as many as 180 hawksbill turtles were killed off the islands of Jana and Karan. Researchers estimated that over 500 sea turtles of both species were killed, including hatchlings, juveniles, and adults, representing significant impacts on both the hawksbill and green turtle populations. The direct and indirect impacts to sea turtles from oil on nesting beaches and other sea turtle habitat remains unknown but the impact likely was severe; Al-Amirah (1985) discussed the turtle habitat hazards created by shoreline oil as it warmed and was mobilized by extreme daytime temperatures.

T/V *Alvenus*, 1984

Figure 5.11. T/V Alvenus, *grounded south of the Calcasieu River, Louisiana in July 1984. Photo: U.S. Environmental Protection Agency.*

On July 30, 1984, the British tank vessel *Alvenus* grounded 11 miles south of the entrance jetties to the Calcasieu River in Louisiana. The ship sustained major structural damage and over the course of the next several days leaked approximately 65,500 bbl of heavy Venezuelan, Merey, and Pilon crude oils. At the time, it was the largest vessel-sourced oil spill into the Gulf of Mexico.

284,000 bbl of crude oil remained on board the *Alvenus* and were lightered over a ten-day period in August. After the cargo was removed, the crippled tanker was towed to Galveston, Texas, for repairs (Alejandro and Buri, 1987).

The heavy crude oils presented several challenges during both salvage and response. The oil was difficult to pump due to its high viscosity and was not amenable to treatment with dispersants for the same reason. In the nearshore areas of the Gulf coast, the high density of the oil, particularly when mixed with sand in the surf zone, caused large amounts of it to submerge just offshore. The US Minerals Management Service (1989) concluded that most of the oil sank to the bottom or formed tarballs in the nearshore zone. Attempts to vacuum or pump the submerged oil were ineffective, leaving eventual beaching as the only viable means for recovery.

Reports of impacts to wildlife were minimal, with one summarizing totals at five bird mortalities, and seven birds and one sea turtle (unspecified species and size) rehabilitated. Shoreline habitats such as mangroves and wetlands also escaped major damage, attributed to the oil being moved away from sensitive shorelines.

T/V *Mega Borg*, 1990

Figure 5.12. T/V Mega Borg, *offshore of Galveston, Texas, June 1990. Photo: NOAA.*

On June 8, 1990, the Italian tank vessel *Fraqmura* was lightering the Norwegian tank vessel *Mega Borg*. The two ships were in the Gulf of Mexico, 57 miles southeast of Galveston Texas, in international waters, but within the U.S. exclusive economic zone. During the lightering process, an explosion occurred in the pump room of the *Mega Borg*. The force of the explosion blew the pump room house off the main deck; it landed midship, killing the pump man on watch. The force of the explosion also ruptured the bulkhead between the pump room and the engine room, both of which caught on fire. Given these developments, the *Fraqmura* conducted an emergency breakaway, during which a relatively small volume of oil (approximately 40 bbl) was spilled.

Subsequently, an estimated 100,000 bbl of Angolan Palanca crude oil was burned or released into the water from the *Mega Borg* over the next seven days. Explosions on the Mega Borg caused the stern of the ship to settle lower in the water and list to the port side, and a continuous discharge of burning oil flowed over the aft port quarter of the ship, extending some 400 feet into the water.

Initially, the highest response priority was to prevent the catastrophic loss of the vessel and its 900,000 bbl of cargo. This required extinguishing the fire and lightering the oil. The firefighting effort would require six vessels and one week to complete; four of the vessels provided cooling water to protect the cargo area and cool the fire, and the remaining two were equipped with the foam systems to put out the fire. The fire was declared extinguished on June 16.

In addition to vigorous skimming operations, there were five applications of dispersants, a total of 11,300 gallons. The effectiveness of these applications in unusually calm sea conditions was ambiguous. A novel bioremediation experiment was also conducted, also with uncertain results.

On June 16, oil stopped leaking from the *Mega Borg*. Over the following days, the surface presence of oil diminished rapidly. Within a week, no surface oil could be detected visually or through the use of side-looking airborne radar (SLAR). Although there was one subsequent episode of tarballs beaching along the Louisiana coast, the response rapidly wound down. On June 27, the *Mega Borg* was taken under tow en route to Pakistan for eventual breaking and scrapping (Leveille, 1991).

During the response, concerns were raised about loggerhead turtles observed near the leading edges of the slick. NOAA made plans to recover at least five of these animals. It is not clear if those plans were implemented, but NOAA conducted some assessment of the effects of the *Mega Borg* spill on sea turtles (Gitschlag 1991). In this study, no turtles were observed swimming in the oil, and only one turtle (a loggerhead) was captured in the waters near the spill. There was no external oiling of this animal, and no indication of internal petroleum contamination based on an analysis of a fecal sample. This turtle was released with a satellite tag and was monitored until the tag ceased transmissions six months later.

This incident occurred in the wake of the *Exxon Valdez* and its contentious damage assessment process. The *Mega Borg* process was more cooperative, and after conducting pre-assessment studies (e.g., Gitschlag, 1991, above) on selected resources, the natural resource trustees ultimately concluded that documented impacts did not warrant a claim for damages against the responsible party (Helton and Penn, 1999).

Gulf War, 1991

Figure 5.13. Aerial photo of extremely heavy shoreline oiling along the coast of Saudi Arabia, January 1991. Photo: NOAA.

Approximately 6 to 8 million bbl of oil was spilled during the Gulf War beginning in late January 1991, the largest oil spill ever recorded in the marine environment. The major sources were four sunken and leaking vessels, including Iraqi oil tankers, and release of oil from the Kuwaiti Mina Al-Ahmadi Sea Island terminal and the Iraqi Mina Al-Bakr loading terminal. An estimated 8 million bbl spilled directly into the Arabian Gulf, forming a 600-square-mile (960 square km) oil slick. Tarmats up to 12 in (30 cm) thick formed on impacted beaches between Safaniya and Abu Ali Island, Saudi Arabia. Cleanup operations recovered over 1 million bbl by April 1991.

Figure 5.14. Observer surveying heavy nearshore and beach oiling along the coast of Saudi Arabia in January 1991. Photo: Bill Lehr, NOAA.

Estimates of the number of sea turtles killed by oil spilled during the Gulf War range from tens to hundreds, but any observations related to these estimates were not well-documented. Fourteen live and four to five dead oiled green turtles, some of which were adults, were found stranded (Pilcher pers. com.). Internal petroleum exposure was also reported from a single stranded green turtle that was not visibly oiled (Greenpeace 1992, cited by Lutcavage et al., 1997). Interestingly, prior to this spill, recommendations for sea turtle conservation in Saudi Arabia had concluded that "…the ongoing high level of oil pollution into the Arabian Gulf must be substantially reduced if sea turtle populations throughout the region are to survive at their current levels" (Miller et al., 1989).

T/B *Vesta Bella*, 1991

Figure 5.15. Surface oil slick above the sunken barge Vesta Bella, *April 1991. Photo: NOAA.*

On March 6, 1991, the barge *Vesta Bella* sank in the Atlantic Ocean approximately 12 miles northeast of Nevis Island (British Virgin Islands). The towing cable for the barge had snapped, and the *Vesta Bella*, carrying 13,300 bbl of No. 6 fuel oil, sank in approximately 2000 feet of water. The cause of the sinking was not determined. The barge was owned by Offshore Marine Limited and operated under the Trinidad flag. Shorelines in the Dutch and French Antilles, or West Indies, were the first to be oiled. However, by March 25, tarballs were noted on Culebra, Puerto Rico, around 200 miles from the source. Other shorelines in Puerto Rico and on St. John were also oiled.

Figure 5.16. U.S. Coast Side-Looking Airborne Radar (SLAR) image of oil slick (upper right) from the sunken Vesta Bella, *April 1991. Photo: NOAA.*

Although skimmers were deployed in mid-April, they were unable to recover significant amounts of oil and those operations ended on April 25. Dispersant use was approved by the Caribbean Regional Response team, and the dispersant Finasol OSR-7 was supplied by the French Navy. Between March 9-15, French and Dutch naval vessels applied the dispersant product near the leak source using the shipboard firefighting equipment; however, it did not appear to be effective on the No. 6 oil and its use was discontinued.

One dead hawksbill turtle (unspecified size) was found oiled near Guayama on the south coast of Puerto Rico and was attributed to the *Vesta Bella* spill (Eckert and Honebrink 1992).

Figure 5.17. Contemporary unimpacted view of Tarague Beach on Andersen Air Force Base, Guam. Photo courtesy of Jonathan Stafford.

Mystery spill, Tarague Beach/Andersen Air Force Base, Guam, 1992

On the morning of February 29, 1992, small patches of heavy, viscous black oil were found on Tarague Beach and several adjacent beaches on Andersen Air Force Base in Guam. The U.S. Coast Guard (USCG) Marine Safety Office (MSO) Guam was notified of the spill by personnel at the Air Force. USCG personnel collected tarball samples from all impacted beaches, samples of oil from impacted wildlife (turtles), and cargo samples from the few identified vessels that had transited the general vicinity. These samples were sent to the USCG Central Oil Identification Laboratory for analysis.

The oil floated in over an extensive reef flat along the north and northeast shores of Guam for less than one mile, impacting several coarse-sand beaches with discrete tarballs one to eight inches in diameter and one-inch thick. The oil did not penetrate the sand.

NOAA and USCG Computer Assisted Search Planning (CASP) hindcasts indicated the source of oil to be offshore east-northeast of Guam. Due to the persistence of No. 6 fuel oil, it was not possible to determine how far offshore the source could have been-anywhere from a few miles to several hundred miles. Overflights of the area failed to find any sign of oil. However, once #No. 6 fuel oil has weathered to tarballs such slicks are almost impossible to spot from the air because they lack sheen.

Impacted beaches were manually cleaned by Air Force personnel. Given the viscosity of the oil and limited quantities that came ashore, no impacts to the coral reef flat fronting the impacted beaches were expected. It was estimated that less than one bbl of oil came ashore.

Three green sea turtles (approximately 20 cm carapace length) covered in black, glossy oil washed ashore on beaches on the north and east side of Guam. This oil behaved as partially weathered No. 6 fuel oil with a pour point above 70° F. Turtles in this size range typically are found in the open ocean and could have been any distance offshore when they were oiled. One turtle found alive was cleaned and returned to the sea. The two dead turtles were given to the Government of Guam Division of Aquatic and Wild Life for analysis. Biologists there speculated that the turtles had mistaken oil for a floating algal mat and surfaced in it. One of the turtles had ingested oil and its nasal openings were clogged with the viscous oil (although sea turtles primarily breathe through their glottis [mouth]).

St. Eustatius refinery, 1992

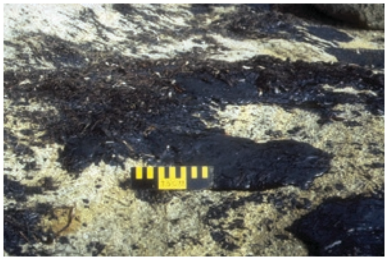


Figure 5.18. Shoreline oiling encountered on Vieques PR, and chemically fingerprinted to St. Eustatius refinery spill, April 1992. Photo: NOAA.

On March 15, 1992, a 24-inch diameter pipe ruptured during ship-to-shore pumping of No. 6 fuel oil to a transfer station at St. Eustatius Terminal on the west coast of St. Eustatius, Netherlands Antilles. The flow rate at the time of rupture was estimated to be 8,000 bbl per hour. Terminal personnel were able to secure the flow about two minutes after the two-foot long rupture occurred. The facility estimated that 200 to 400 bbl of No. 6 fuel oil had been released. Initial reports of the slick ranged from 9 to 20 nautical miles long and an unknown width, extending out over the Saba Bank. Dispersant operations were immediately initiated by applying Jan-Solv 60 from a tug. It was also reported that Corexit products (9527 and 9517) were sprayed on the slick.

Figure 5.19. Dead green turtle encountered during shoreline survey for oil related to St. Eustatius refinery spill on Vieques, PR. Photo: NOAA.

Beginning on April 8, large tarmats and tarballs were discovered on the southwest end of Vieques Island (Puerto Rico). Impacts were also found on the southeast corner of Puerto Rico from Roosevelt Roads Naval Base to Playa De Humacao, as well as on beaches in St. John and St. Thomas, USVI. Samples of the oil that came ashore in Puerto Rico were analyzed by LSU and the USCG COIL labs and were confirmed to have originated from the St. Eustatius spill of March 15.

Two dead and oiled turtles (1 green – juvenile of unspecified size, 1 hawksbill – unspecified size) were found on Vieques during shoreline surveys (Figure 5.19). The turtles were reported to have been collected for necropsy, but no additional information is available.

Tampa Bay Multiple-Vessel Collision, 1993

Figure 5.20. Barge Ocean 255 *ablaze in Tampa Bay, August 1993. Photo: U.S. Geological Survey.*

On August 10, 1993, the freighter *Balsa 37*, the barge *Ocean 255*, and the barge *Bouchard 155* collided in the shipping channel west of the Skyway Sunshine Bridge, south of Mullet Key in Tampa Bay, FL. This collision caused three separate emergencies: 1) the Balsa 37, which was carrying a cargo of phosphate rock, was severely damaged and was in danger of capsizing in the channel; 2) the *Ocean 255*, which was loaded with jet fuel, gasoline, and a small amount of diesel fuel, was burning out of control just south of Mullet Key; and 3) the *Bouchard 155* was holed at its port bow, spilling approximately 8,000 bbl (336,000 gallons) of No. 6 fuel oil into Tampa Bay.

By August 15, most of the floating oil had washed ashore and coated approximately 14.5 miles (23 km) of sand beach, several mangrove islands, and seawalls. On some sand beaches, oil was buried by several centimeters of clean sand deposited during high tides. Large, thick oil mats coated mangrove roots, oyster beds, seagrass beds, and tidal sand flats around four mangrove islands in Boca Ciega Bay. The oil was very heavy

Figure 5.21. Loggerhead hatchling recovered during the Tampa Bay spill response, August 1993. Photo: NOAA.

and emulsified, and large oil patches submerged and stabilized in the bay sediments, and some offshore areas. Several large, contiguous, thick mats of submerged oil were found just offshore of Gulf of Mexico beaches in 6 to 20 feet (~2 to 6 m) of water and inside the entrance to Boca Ciega Bay at John's Pass and Blind Pass.

Cleanup of impacted sand beaches consisted primarily of manually removing the surface oil, mechanically removing subsurface oil, and "surf-washing" stained sand. Heavy equipment such as front-end loaders and graders were used for sand removal and "surf-washing" (pushing oiled sand into the surf zone to re-float oil for collection). Final beach grooming was done with graders and disking equipment, normally to a depth of 12 in (30 cm). Oil around the mangrove islands was vacuumed (Figure 4.13) using grounded barges staged in shallow sand flats, followed by manual removal within the mangrove edges. Submerged oil patties and tarballs were also removed manually. Attempts were made to vacuum submerged oil mats west of Eleanor Island in Boca Ciega Bay, but it is unclear whether this operation was considered to be successful.

Figure 5.22. A juvenile green turtle oiled during the 1993 multi-vessel incident in Tampa Bay, Florida. Photo courtesy of Dr. Anne Meylan, Florida Marine Research Institute.

Sea turtle nesting beaches and foraging areas were oiled, then disturbed by cleanup operations. Loggerhead, Kemp's ridley, green, and hawksbill turtles occurred within the affected area. The Natural Resource Damage Assessment report from the incident summarized known impacts (Florida Department of Environmental Protection et al., 1997). Most of the impacted nests and nesting activity was associated with loggerhead turtles. Four loggerhead hatchlings were recovered dead, and twelve live hatchlings (Figure 5.21) required intervention. Of these twelve, three were oiled, two were trapped behind boom with oil, and seven had no trace of oil but were disoriented by lights associated with the response. All were eventually released. One oiled, live juvenile green turtle was recovered offshore, in an oiled windrow, and was cleaned and released (Figure 5.22).

Many loggerhead nests on beaches in the spill area had not yet hatched: 115 nests were marked as being at risk, 96 were on oiled beaches, 14 had to be protected by booms or trenches, 2 were inundated with oil, and one unmarked nest was run over by a bulldozer. The two nests inundated by oil had a lower than normal hatching success rate (5 percent of eggs, compared to 50 to 90 percent normally). The nest run over by a bulldozer had five crushed eggs; the remaining eggs were transplanted but less than a third hatched. Of the remaining nests, hatchlings emerged from 29 during the response. Most of these hatchlings (1,530 loggerheads from 23 nests), including were restrained and released into the water in Sarasota County. Approximately 413 hatchlings from the other 6 nests were not restrained and entered waters that may have contained oil. An estimated 27 loggerhead hatchlings from a nest at Egmont Key State Park were likely taken by predatory birds after they emerged during the response and were impeded from reaching the water by a containment boom left on the beach. Overall, approximately 212 hatchlings were killed, and 2,177 were potentially injured by oil exposure and response activities.

For more than a year after cleanup, unrecovered submerged and buried oil chronically oiled beaches in the Tampa area during storms. Submerged oil entrained in bottom sediments of sheltered coastal inlets was uncovered in January 2000, several years after the spill, during inlet dredging and beach renourishment (Upham Beach) at Blind Pass Inlet. Initial dredging operations remobilized the oil, which had weathered very little because it was buried. The oil washed ashore as tarballs and patties and coated some shorelines. The possibility of mobilization of submerged oil during these activities or storms, as well as placement of dredged oiled sand on renourished beaches, caused concern about potential impacts on sea turtle nesting areas. Sea turtles begin nesting in the area in early May. In response to these concerns, submerged oil in Blind Pass and John's Pass was removed in conjunction with the dredging and beach renourishment program. Dredged sand and oil were allowed to separate, and the clean sand was used on beaches as part of the beach renourishment operations. Monitoring of nesting beaches verified that no oil was deposited as a result of these operations.

Barge *Morris J. Berman*, 1994

On January 7, 1994, the tank barge *Morris J. Berman* grounded on hard rocky and coral bottom in the surf zone 300 yards (274 m) off San Juan, Puerto Rico. The barge drifted ashore after the towing cable parted from its tug. The barge was carrying heavy No. 6 fuel oil, which began discharging immediately and impacting nearby shoreline and shallow intertidal habitats. Oil was lightered off the *Morris J. Berman* to another barge until it became too viscous and difficult to pump. Oil continued to leak from the barge and re-oil the nearshore environment for several days, until the vessel was refloated, towed to a scuttling site 20 nautical miles (32 km) northeast of San Juan, and sunk.

Figure 5.23. Barge Morris J. Berman *aground off San Juan, Puerto Rico, January 1994. Photo: NOAA.*

More than 48 km of Puerto Rico's north shore were ultimately fouled by the spilled oil. Two shallow lagoons near the grounding site acted as natural catchment areas and oil accumulated on the surface and bottom in large mats. In early February, oil impacted shorelines in northwestern Puerto Rico, when debris and oil released by the scuttling of the barge came ashore. Some oil was buried, forming oily sand layers, and some oil submerged in sheltered areas and bays in the form of oil and sand mats.

Potential impacts to sea turtles and other wildlife were a major concern during response. Intensive cleanup efforts began in the affected shoreline areas immediately because nesting sea turtles were due to arrive within weeks. Guidelines developed by natural resource trustees and response agencies to minimize cleanup impacts addressed sand removal, nighttime activities, use of all-terrain vehicles and other equipment, and any other cleanup operations that might impact sea turtles or their nesting habitats. Sand beaches contaminated with oil deposits were cleaned by manual removal, taking precautions to minimize sand removal. Heavy equipment, including backhoes and front-end loaders, was used to remove large areas of heavily oiled sand and buried tar mats. Machinery movements were closely monitored to prevent unnecessary traffic across the beach and sand dunes. Wood-frame and chicken-wire screens were used to sieve scattered tarballs out of the sand in some areas. Submerged oil was removed by manual collection using divers, vacuum transfer units, pumps, and submersible dredges. Beach rock, riprap, and seawalls were cleaned with pressure washers and chemical cleaners. Oil in some locations was left to weather naturally due to inaccessibility, low levels of human use, or exposure to high-energy waves.

During the response, two oiled green turtles were recovered, cleaned, rehabilitated, and released by the Puerto Rico Department of Natural Resources and Caribbean Stranding Network facilities in San Juan. One turtle was oiled on its neck, flippers, and back; the other one had patchy oiling. At least three additional oiled sea turtles (one green and two hawksbills) were collected, but the oil in these cases was not attributed to the *Morris J. Berman* spill. In addition to turtles, thousands of live and dead oiled organisms washed ashore, including birds, invertebrates, and fish.

Fort Lauderdale, Florida, Mystery Spill, 2000


JOHN U. LLOYD STATE PARK

Oil jeopardizes baby turtles

Volunteers, rangers save hatchlings that could otherwise suffocate or drown.

Figure 5.24. Newspaper coverage of the mystery spill that affected the southeast coast of Florida in August 2000. Courtesy of South Florida Sun-Sentinel, reproduced with permission.

On August 8, 2000, a spill of unknown origin began washing up along Florida's east coast from North Miami to Pompano. Tarballs from 0.25 in (64 mm) to pancake and mat size impacted several beaches, sometimes mixed with wrack. The oil release, whose source was never identified, was ultimately estimated at more than 20,000 gallons of a heavy product resembling an intermediate fuel oil. Submerged oil mats and patties, unevenly distributed and of varied sizes and thicknesses, were also found in nearshore troughs from John U. Lloyd State Park to Hollywood Beach. The submerged oil mats were sticky, mixed with seagrass and sediment, and in some areas formed large continuous accumulations, much of it buried under a thin layer of sand. Oiled shorelines were manually cleaned within days; some submerged oil was removed manually by divers.

Hatchling sea turtles were a priority concern during this incident. At the time of the spill, there were an estimated 530 sea turtle nests on beaches in the area. In John U. Lloyd State Park (Figure 5.24), one of the most heavily impacted areas, 43 surveyed nests were expected to hatch within days of the oil stranding. Eight were green turtle nests, the remainder were loggerhead nests. In addition to potential impacts from shoreline oiling, the submerged oil and tarballs presented a serious risk to hatchlings and turtles swimming nearshore.

Known sea turtle nests were monitored 24 hours a day, and hatchlings were captured for transport to and release within clean areas. Beaches were monitored for new tarball strandings and cleaned immediately. Stricter cleanup standards were established for turtle nesting beaches than other impacted areas (no more than 5 percent oil cover). Volunteers raked areas seaward of turtle nests to clear wrack and tarballs.

More than 137,000 loggerhead, green, and leatherback hatchlings were estimated to have been potentially exposed to oil. Natural Resource Damage Assessment (NRDA) modeling also estimated that over 70 adult (mostly nesting females), and over 300 post-pelagic juvenile sea turtles in the area were potentially exposed to oil. The modeling indicated that 1 percent of adult and 50 percent of hatchlings in the path of the oil died, although no dead, oiled turtles were recovered. This translated into the assumed deaths of approximately 7,800 hatchlings, 0.5 post-pelagic juveniles, and 0.12 adult turtles (Jeansonne et al., 2005). Loggerheads, which were the most abundant species in the area, were assumed to have been numerically most impacted by this spill in terms of total number exposed and injured.

T/V *Jessica*, 2001

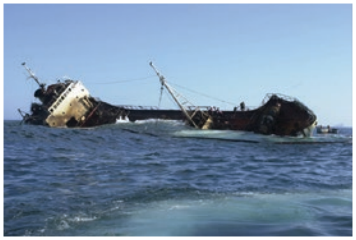


Figure 5.25. T/V Jessica, *grounded on Shiavioni reef at the entrance of Wreck Bay, Isla San Cristóbal, Galápagos, January 2001. Photo: PACS Tod Lyons, U.S. Coast Guard.*

On January 16, 2001 the tanker Jessica, owned by Acotramar C.A., ran aground in heavy weather at the entrance to Puerto Baquerizo Moreno, in Wreck Bay, on San Cristóbal Island, Galápagos. The Galápagos Islands, of course, are one of the most important biological reserves in the world. The archipelago is a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage site. It is also a National Park (Ecuador) and a Maritime Nature Reserve, known for its unique endemic species and distinguished role in biological history. It comprises twelve islands and covers an area of 450 sq. km.

The *Jessica* was carrying about 600 tons (3,800 bbl) of diesel oil and 300 tons (1,900 bbl) of intermediate fuel oil (IFO 120). The diesel was to be delivered to the fuel dispatch station on Baltra Island, with the IFO was destined for the tourist vessel *Galapagos Explorer*. The IFO began leaking on January 20, and personnel of the Galápagos National Park, the Ecuadoran Navy, fishermen, and local volunteers worked to contain and recover the oil on the surface of Wreck Bay. Despite the rapid action taken by the responders, the slicks started drifting west-northwest, pushed by winds and current. The oil hit the islands of San Cristobal and Santa Fe, where sea lions and sea birds were affected. The slicks then moved on to threaten the islands of Santa Cruz and Isabela with their colonies of pelicans.

Response teams from the European Union and the United States arrived to provide assistance with containment and cleanup. Approximately 119 bbl of IFO and 1,300 bbl of diesel were removed from the crippled tanker by the U.S. Coast Guard

Gulf Strike Team, the Ecuadorian Navy, and local fishermen. By January 29, most of the remaining 4,285 bbl of fuel oil (1,785 bbl of IFO 120 and 2,500 bbl of diesel) had escaped from the hull and dispersed within the archipelago, primarily to the west and southwest. Apparent slicks of the lighter diesel fuel were reported near all islands south of Marchena. The heavier IFO had washed ashore on sections of San Cristóbal, Santa Fé, Santa Cruz, Floreana, Isabela and Fernandina, some smaller islets, and may have reached other islands. Seabirds, marine iguanas, sea lions, sea turtles, fishes, and other organisms were fouled by fuel as far away as Genovesa and Fernandina.

Lougheed et al. (2002) summarized impact assessments shortly after the spill. There was a tremendous amount of concern worldwide about potential damages to the species and ecosystems of the Galápagos archipelago from this oil spill. Although some acute impacts such as one mortality, conjunctivitis, and skin burns were documented in sea lions, longer-term population declines were determined to be insignificant within a year (Salazar, 2003). Marine iguanas were suggested to have suffered the most serious oil-related injuries, but linkages were not well-defined beyond demonstration of elevated stress hormones and speculation about possible alteration of gut bacteria required for digestion. In the case of sea turtles, Lougheed et al. documented eight live, oiled adult green turtles around San Cristóbal Island. None were captured.

Figure 5.26. Aerial view of Mississippi Block 69 pipeline leak on September 28, 2004. Photo: Louisiana Department of Environmental Quality.

Mississippi Block 69 Pipeline Leak, 2004

In September 2004, Hurricane Ivan damaged several oil facilities and pipelines in the Mississippi River Delta region of Louisiana. On 23 September 2004, an overflight reported a 6 mile by ½ mile slick from a source in the vicinity of Pass a Loutre within Mississippi Block 69, just under 3 miles north of the North Pass. Two 20-inch pipelines suspected to be the source were shut in (secured), but oil continued to be released. Two offshore skimming vessels were deployed and dispersant operations were considered because several exposed sand bars (sand islands) at the mouth of North Pass with large concentrations of birds were impacted; the U.S. Fish and Wildlife estimated more than 2,000 birds were at high risk.

Dispersants were initially applied from a vessel near the observed source of oil, but this was halted due to unfavorable weather conditions. Skimming operations continued. When the weather abated, the footprint of the surface oil slick was found to be much larger, and dispersant application planning was expanded to include the use of DC-4 and DC-3 aircraft. A priority for dispersant use was to treat oil slicks adjacent to wildlife areas. During wildlife surveys, U.S. Fish & Wildlife representatives observed two loggerhead sea turtles in oil aggregated in a convergence line with associated debris and vegetation. However, the turtles appeared to be behaving normally.

The pipeline leak, while not specifically pinpointed, was secured by October 2, through a series of temporary patches and containment measures. However, oil continued to be observed on the water raising concerns about the extent and effectiveness of containment. The leak was finally controlled by forcing oil out of the pipeline with seawater and collecting it with a containment dome; after which surface oiling was substantially reduced. There were no additional reports of sea turtles impacted by oil.

M/T *Vicuña*, 2004

On November 15, 2004, the Chilean flagged chemical tanker *Vicuña* exploded while unloading its cargo of methanol in the port of Paranaguá, Brazil. Four people were killed, the ship was destroyed, and numerous buildings and facilities at the terminal were damaged. The methanol cargo was a total loss, mostly evaporating, and fuel oil from the ship's tanks (estimated at 291,000 L.) was released into the environment (Brazilian Navy, 2005).

Reported wildlife deaths included 14 sea turtles (unspecified species and sizes) and 2 dolphins (ITOPF, 2005); however, it was unclear if all of the animals died as a result of the spill (Sea Alarm Foundation, 2009; V. Ruoppolo, Aiuká Consultoria em Soluções Ambientais, pers. comm., September 29, 2017). The International Fund for Animal Welfare (IFAW) worked with three local wildlife organizations to rehabilitate oiled animals. A Petrobras mobile wildlife rehabilitation center for seabirds was set up, and four search and rescue boats attempted to locate and capture oiled wildlife. No sea turtles were captured alive and cleaned.

Figure 5.27a & b. M/T Vicuña *at Cattalini Terminais Marítimos Ltd terminal, Paranaguá, Brazil, November 16, 2004. Photos courtesy of Association Française des Capitaines de Navires (AFCAN).*

Figure 5.28. M/T Vicuña *at Cattalini Terminais Marítimos Ltd terminal, Paranaguá, Brazil, Novmber 2004. Photo: Brazilian Navy, Directorate of Ports and Coasts.*

Jiyeh Electric Power Plant, Lebanon, 2006

In 2006, hostilities between Israel Defense Forces and Hezbollah militants escalated to military conflict and resulted in a 34-day war that targeted not only Hezbollah military installations, but also Lebanese civilian infrastructure. Between July 13-15, 2006, Israel bombed the Jiyeh power plant located on the Lebanese coast around 30 km south of Beirut, where 75,000 tonnes of intermediate fuel oil (IFO) was stored; the Lebanese government estimated that as a result of the Israeli bombing runs, 55,000 tonnes were burned and 12,000-15,000 tonnes spilled into the eastern Mediterranean Sea. The spill impacted about 140 km of rocky, sandy, and gravel beaches along the Lebanese coast (CEDRE, 2006; Khalaf et al., 2006), including sea turtle nesting beaches.

Khalil et al. (2009) monitored the effects of the war on sea turtle populations and nesting sites in southern Lebanon, which included three important nesting areas for Mediterranean green turtles and loggerheads. Oil from the Jiyeh power plant primarily

Figure 5.29. Members of the Lebanese army observing the placement of protective mesh over a sea turtle nest on El Mansouri and El Koliala beach in southern Lebanon in 2006. Source: Khalil et al. (2009).

impacted shorelines to the north; the beaches to the south, according to Khalil et al., were spared. Monitoring efforts focused on the southernmost beach of El Mansouri and El Koliala, which is located around 20 km. from the Lebanese-Israeli border. This beach had been regularly monitored for five years prior to the war. Between 2002 and 2007, the number of loggerhead nests at this beach varied between 33 and 67; green turtle nests ranged from 0 to 9 nests. The effects of the spill on nesting are unclear due to multiple complicating factors, especially the associated armed conflict. Interestingly and ironically, the highest number of sea turtle nests occurred in 2006, the year of the war. Because many of the impediments to turtle nesting along the Lebanese coast can be attributed to human activities (i.e., beach disruptions, fishing, presence of dogs), the hostilities in 2006 may have curtailed these threats thus allowing turtles to nest more successfully. On the other hand, Israeli bombs and shells directly damaged beaches, and Lebanese soldiers were stationed on the beach. In addition, foxes that possibly were driven from the adjacent hills by artillery and bombs joined dogs as nest disruptors and predators. Foxes proved to be persistent raiders, damaging between 11 and 17 percent of nests in 2007 and 2008, despite protection efforts.

The Lebanese example illustrates not only the many human-induced pressures on sea turtle populations, but also the perseverance of those people committed to protecting them. The sea turtle monitors at El Mansouri and El Koliala left only when bombs fell dangerously close to their beach; and they returned after two weeks to begin repairing war damage and continue their work monitoring the well-being of the turtles.

Figure 5.30. M/V Pacific Adventurer. *Photo: Australian Maritime Safety Bureau (ATSB).*

M/V *Pacific Adventurer*, 2009

On March 11, 2009, the cargo vessel *Pacific Adventurer* was en route to the Port of Brisbane in Moreton Bay, Australia when it encountered Cyclone Hamish. In the midst of the storm, 31 containers of ammonium nitrate were lost overboard, some of which struck and damaged the hull of the ship in heavy seas. The resulting impacts tore two holes into the hull, one of which was not found until the ship was inspected by divers dockside in the Port of Brisbane. The initial damage was reported to the No. 1 fuel tank; the subsequently identified breach below the waterline was to a starboard bunker fuel tank (AMSA, 2010a). First reports of oil loss were 20 tons (around 137 bbl), but these were incrementally revised upward to 270 tons (1847 bbl).

The released heavy fuel oil impacted the southeastern coast of Queensland, including portions of a national park, Bribie and Moreton Islands, and the amenity beaches of the Sunshine Coast. Shoreline cleanup involving as many as 2,500 people took place over a period of two months, although recovery (restoration) activities continued into July of 2010.

Figure 5.31. Hull damage to M/V Pacific Adventurer, *annotated by Australian Transport Safety Bureau (ATSB). Photo: ATSB (2011).*

Although the spill area was rich with wildlife, relatively few affected animals were documented. Only one bird mortality and two sea snake deaths were directly attributed the oil spill. Two oiled green turtles (one live, one dead, of unspecified size) were also encountered, but were judged to have been in poor health unrelated to oil exposure. The living turtle was rehabilitated and released. Oil was not determined to have been the cause of death of the deceased turtle based on necropsy. A number of sea turtle strandings occurred during or shortly after the response, but were not attributed to the spill (Short, 2011).

In addition to individual animals encountered during the spill, 22 green turtle nests were identified on Sunshine Coast beaches. To prevent potential exposure to oil on the sand beaches after hatching, the nests were enclosed in cages and hatchlings were transported to oil-free areas north of the spill zone.

Montara Platform/*West Atlas* Rig, 2009

Figure 5.32. Aerial view of the Montara platform in August 2009. Photo: Mark Hamilton, Australian Maritime Safety Authority (AMSA).

On August 21, 2009, the Montara Platform (owned by PTT Exploration and Production Public Company Limited, PTTEP) and the *West Atlas* mobile drilling unit (SeaDrill Ltd.) suffered a blowout, resulting in the uncontrolled discharge of a light, waxy crude oil and gas from a well designated as H1 into the Timor Sea on the continental shelf of Australia. The discharge of oil was stopped 74 days later, on November 3, 2009. Estimates of the amount of oil released vary widely; Burns and Jones (2016) estimated the total to have been 4.7 million liters (1.2 million gallons), resulting in a surface slick covering 90,000 sq. km.

Offshore skimming operations were credited with the recovery of 844,000 liters of oil-water mix, of which 493,000 liters was estimated to have been oil. Aerial applications of six different types of chemical dispersants took place between August 23 and November 1, 2009. A total of 162,000 liters were sprayed (AMSA, 2010b).

The platform was located 135 nautical miles offshore from the northwest Australian coast and around 108 nautical miles from Pulau Rote, Indonesia. There were surprisingly few reports of reef or shoreline impacts despite the duration of the uncontrolled release and the volume of oil spilled. These reports consisted of scattered, minor sightings of sheen or paraffinic wax.

After 4 unsuccessful attempts and approximately 10 weeks after the blowout, a relief well successfully intercepted the H1 well on the morning of November 1, 2009. Heavy mud was pumped into H1, and while the flow was slowed, an insufficient amount of mud was available to completely kill the well. A heavier mud was pumped into the well on November 3, and flow was finally halted after 75 days (Borthwick, 2010).

There was a demonstrated awareness of resources at risk during the Montara response, by both governmental and non-governmental organizations. However, Spies et al. (2017) noted that formal monitoring for impact assessment began well after operational and response activities. Watson et al. (2009) performed a rapid assessment of resource impact that covered cetaceans, birds, and marine reptiles (snakes and turtles). Turtles were infrequently observed on the designated transects, but 10 turtles (4 loggerhead, 2 green, 4 unidentified) of a total of 25 sightings were observed in oil. In addition, a non-governmental survey conducted for the World Wildlife Fund (Mustoe, 2009) approximately one month after the blowout began documented hawksbill and flatback turtles in areas of oil sheen. Gagnon and Rawson (2010) reported results of a necropsy performed on a green turtle recovered from Ashmore Reef, northwest of the blowout location. There was no visible evidence of either external or internal oiling, and both swabs and tissue chemistry showed no sign of contamination by petroleum.

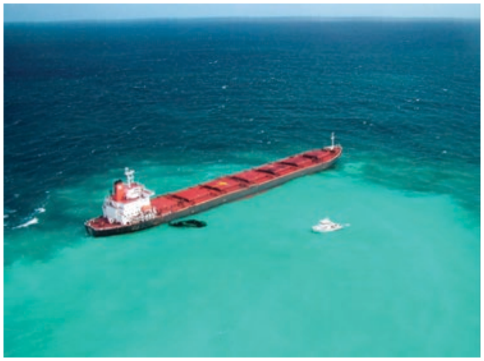


Figure 5.33. M/V Shen Neng 1 *grounded near the Great Barrier Reef, Australia, April 2010. Photo: ©Maritime Safety Queensland.*

M/V *Shen Neng 1*, 2010

On April 3, 2010, the cargo vessel *Shen Neng 1*, transporting 65,000 tonnes of coal to China, ran aground on Douglas Shoal near the Great Barrier Reef in Australia. The grounding ruptured a fuel tank, from which 3 tonnes of fuel oil escaped. The spill response included deployment of skimming vessels and application of dispersants from fixed-wing aircraft.

The ship was over 30 km off course when it grounded 70 km off the coast of Queensland. The Australian Transport Safety Bureau confirmed that the ship had taken an illegal shortcut. Complicating the action, the crew failed to reset the GPS and as a result the ship missed the passage it should have taken. Finally, the quartermaster was believed to have been asleep while steering the vessel (CEDRE, 2011).

After lightering 400 tonnes of oil and water mixture from the grounded ship, the *Shen Neng 1* was refloated with no further loss of oil on April 12. However, plans to tow the ship to the Port of Gladstone for repairs were stymied by poor weather and instead it was taken to an alternate location where 19,000 tonnes of coal could be offloaded to other vessels. Finally, on May 21, following salvage operations, the ship was permitted to depart Queensland waters under tow to Singapore for repairs and to discharge the rest of its cargo.

The Shen Neng 1 incident resulted in a 3 km/400,000 sq. m. scar that the Great Barrier Reef Marine Park Authority termed the greatest known direct impact on a coral reef by a ship grounding. The scar is predicted to persist for decades. While the amount of oil that was released was relatively small, tarballs were observed to wash up on the known bird rookery and sea turtle (green and loggerhead) nesting site, North West Island. There were no reports of injury to nesting turtles, eggs, or hatchlings.

Deepwater Horizon/Macondo Wellhead, 2010

Figure 5.34. Mobile offshore drilling unit Deepwater Horizon *ablaze in the Gulf of Mexico, April 21, 2010. Photo: U.S. Coast Guard.*

On April 20, 2010, the *DWH* mobile drilling unit exploded and eventually sank in the northern Gulf of Mexico, nearly 64 km from mainland Louisiana. In addition to the tragic loss of 11 human lives and 17 injured people, approximately 3.19 million bbl of oil were released into the ocean over 87 days following the initial explosion. The spill contaminated over 112,000 km^2 of surface waters, 2,100 km of shoreline, and affected a wide diversity of biotic and abiotic natural resources in the Gulf of Mexico marine ecosystem. The *DWH* spill footprint covered the range and habitat of all 5 sea turtle species found in the Gulf from open ocean to coastal areas, including nesting beaches. The pervasive and prolonged nature of the DWH spill and related response activities meant that sea turtle exposures to *DWH* oil and resulting injuries were inescapable for many turtles.

Response efforts included an unprecedented use of chemical dispersants, hundreds of controlled burns, deployment of boom to prevent oil from reaching sensitive coastal areas, and mechanical collection of oil from the water's surface and shorelines. Hundreds of sea turtles were rescued from habitat affected by oil and cleanup efforts. On nesting beaches, response actions to remove oil resulted in decreased nesting in Alabama and the Florida Panhandle. In addition, eggs were translocated from the Gulf of Mexico to the Atlantic coast of Florida to prevent hatchlings from entering the Gulf during the oil spill, potentially resulting in the loss of these hatchlings from the Gulf aggregations.

Under the *DWH* NRDA, a multifaceted effort was undertaken to assess oil exposure and injury to sea turtles caused by the spill, including vessel-based rescues and veterinary assessments, aerial surveys, satellite tracking of live sea turtles, recovery and post-mortem examination of dead sea turtles, and monitoring of nesting sea turtles and their nests. Approximately 1,800 sea turtles, across all life stages, were directly observed within the cumulative DWH oil footprint. A key action undertaken was vessel-based rescue of small juvenile (oceanic) sea turtles in open-ocean convergence areas, which

Figure 5.35. (top left) Responders searched convergences areas where oil, pelagic Sargassum, *and turtles were aggregated during the* Deepwater Horizon *spill. (top right) When turtles were observed, responders attempted to rescue them from the surface using dipnets. (bottom left, right) Oiled turtles were brought aboard rescue vessels, examined, and cleaned. Turtles were then taken to rehabilitation facilities to receive extended veterinary care until they were ready for release. Photo (bottom left) courtesy of T. Hirama, Florida Fish and Wildlife Conservation Commission. Other photos courtesy of Blair Witherington, Florida Fish and Wildlife Conservation Commission.*

provide important habitat for this life stage of turtle and also accumulated surface oil from the *DWH* spill. These rescue operations documented more than 900 turtles within the *DWH* spill zone, facilitated direct observations of degree of oiling and veterinary assessment of rescued turtles, and incorporated regimented search methods that ultimately allowed NRDA practitioners to estimate the total number of turtles impacted within the spill area. Of the turtles observed, 574 were captured and examined for oiling, and 464 (>80%) were visibly oiled. More than 90% of turtles taken to rehabilitation facilities for further medical evaluation, treatment, and monitoring survived and were eventually released. However, the *DWH* NRDA Trustees estimated that nearly 500,000 sea turtles across life stages and species were exposed to oil, and between 95,000 and 203,000 died. In addition, it was estimated that between 843-1749 km^2 of *Sargassum* habitat was impacted.

Overall, adverse physical effects of miring in heavy oil caused the most apparent and severe harm to sea turtles during the *DWH* spill. Heavily oiled turtles were unlikely to have survived without intervention. Both external and internal exposure to oil were extensive for small oceanic juveniles due to the dependence of these animals on surface habitats where oil accumulated. Similar concerns about miring in surface oil were warranted for larger turtles exposed to surface oil based on limited observations of impaired, oiled, larger turtles during the DWH spill and previously published reports of oiling associated with death or stranding.

As described in Chapter 3, adverse effects of *DWH* oil toxicity were difficult to identify conclusively. Oiled turtles that were rescued showed some non-lethal abnormalities that were attributable to stress and exhaustion from oiling, capture, and prolonged handling; these abnormalities resolved with medical treatment. Further, a toxicity study that freshwater turtles given *DWH* oil by ingestion did not result in morality or apparent life-threatening effects following a two-week exposure regimen. Hatchling loggerheads exposed to DWH oil with and without dispersant exhibited reduced weight gain, an effect that may be attributed to reduced consumption of contaminated water. The effects of longer-term exposure, as likely occurred during the *DWH* spill, have not been studied.

Texas City "Y", 2014

On March 22, 2014, the bulk carrier M/V *Summer Wind* collided with the oil tank-Kirby Barge *27706*. The incident occurred in Galveston Bay near Texas City, Texas, and resulted in the barge spilling approximately 168,000 gallons of intermediate fuel oil. The oil spill would become known as "Texas City Y" because the collision occurred near the intersection of three major waterways - the Houston Ship Channel, the Texas City Ship Channel, and the Gulf Intracoastal Waterway. Most of the spilled oil came ashore on shorelines between Galveston and Matagorda Islands, although there were also impacts inside Galveston Bay proper.

Over the first two weeks of the response, between March 22 and April 5, a total of 22 stranded sea turtles were documented in the two operational zones of Galveston Bay and Matagorda. Six animals (4 dead) were encountered in Galveston; 16 turtles (13 dead) were found on Matagorda Island. Two dead turtles, both juvenile Kemp's ridleys, were found dead and noted in the field to have small areas of oil on them, but one was later determined to be algae mistaken for oil. Both animals were too decomposed or scavenged to provide a conclusive necropsy.

Figure 5.36. Kirby Barge 27706, loaded with marine fuel oil and partially submerged in the Houston Ship Channel, March 22, 2014. The bulk carrier Summer Wind *collided with the barge, containing 924,000 gallons of fuel oil. Photo: U.S. Coast Guard.*

Ennore Spill, 2017

On the morning of January 28, 2017, the liquefied petroleum gas tanker *BW Maple* and the chemical tanker *Dawn Kanchipuram*, collided two nautical miles off Kamarajar Port, in Ennore, India. The damaged *Dawn Kanchipuram* leaked an estimated 196 metric tons of a heavy oil ("furnace oil") that contaminated around 52 km of shoreline (Selvakumar et al., 2017; Prasad et al., 2018). The oil was a thick, viscous product that readily adhered to beach substrate. A considerable portion of the cleanup activity was manual collection by volunteers, with some use of high-pressure washing to mobilize oil from boulders and cobbles into collection areas (Han et al., 2018).

The incident unfortunately occurred during the January-May olive ridley nesting season on the Bay of Bengal beaches south of the spill location. Selvakumar et al. (2017) photo-documented a dead, oiled olive ridley sea turtle, as well as oiled nesting location beach, oiled egg, and briefly described turtles having been suffocated by oil and effects on nesting beaches. Several news reports also pictured oiled sea turtles on the shorelines and attempts to move them; it was unclear whether the animals were being moved for rehabilitation, or for relocation. However, sea turtle deaths, nesting impacts, or other effects from this spill have yet to be documented in detail in the form of available technical reports or scientific publications.

Figure 5.37. Manual cleanup of oil from the Ennore oil spill, 2017. Photo: Han et al. (2018), courtesy of P. Clement, Center for Water Quality Research, University of Alabama.

Oil spills and sea turtles: looking ahead

Review of the case history files permits us to identify some common factors and to define some areas of concern or opportunities for improvement. For example, listing sea turtles in a spill notification phase has not always been consistent: turtles are sometimes listed as resources at risk, and other times not. Sea turtles or turtle habitat were a concern in only about half the actual or potential spills within their geographic ranges (Chapter 1). Turtles and nesting beaches are more frequently mentioned in response progress reports, but in many cases were not mentioned at all, even for incidents that occurred in known turtle habitat. These omissions suggest that the incidents were either not considered a real risk to sea turtles despite the potential or that the threat was overlooked.

The body of case histories does not demonstrate a pattern of significant impact from oil spills to sea turtles, suggesting the possibility that sea turtles have not been seriously affected by most spills, with some notable exceptions (e.g., the *DWH* spill). It is more likely, however, that impacts on turtles were not actively targeted for assessment, or were only discovered after response actions were terminated. Therefore, future response and damage assessment efforts should incorporate recommendations and best management practices specific to sea turtles to ensure that adequate information is collected to both minimize harm and quantify the full nature and extent of injuries to turtles caused by spills. Such efforts are essential for sufficient restoration.

While we cannot predict the future, trends over the past provide at least a few clues as to what may occur in the future. The typical spill that NOAA responded to in waters frequented by sea turtles at the conclusion of the last millennium involved a vessel grounded nearshore and spilling about 100 bbl of diesel or No. 2 fuel oil. The typical vessel was a freighter, bulk carrier, or fishing vessel. However, things change. The dynamic nature of global markets, areas of oil production, and modes of transport—all with the spectre of climate change looming over them— would suggest that the protection of sea turtles and their habitats, both in the U.S. and worldwide, will require response planners to be prepared to address small- and medium-sized fuel oil spills in addition to infrequent catastrophic large releases. Regardless of the size, mode, or type of oil spill: the knowledge gained from prior spills can be used to inform response planning in a manner that accounts for the specific needs of sea turtle species and life stages at risk.

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Acronyms

ACP: Area Contingency Plan

AMSA: Australian Maritime Safety Administration

ATSB: Australian Transport Safety Bureau

ATSDR: Agency for Toxic Substances and Disease Registry

bbl: barrel(s)

BMP: Best Management Practice

CEDRE: Centre of Documentation, Research, and Experimentation on Accidental Water Pollution

CERA: Consensus Ecological Risk Assessment

CFR: Code of Federal Regulations

CITES: Convention on International Trade in Endangered Species of Wild Fauna and Flora

CRRT: Caribbean Regional Response Team

DOI: U.S. Department of the Interior

DPS: Distinct Population Segments (under ESA)

DWH*: *Deepwater Horizon

ERMA: Environmental Response Management Application

ESA: Endangered Species Act

ESI: Environmental Sensitivity Index map

FOSC: Federal On-Scene Coordinator

FP: Fibropapillomatosis

GNOME: General NOAA Operational Modeling Environment

HAB: Harmful Algal Bloom

IAC: Inter-American Convention for the Protection and Conservation of Sea Turtles

ICS: Incident Command System

ITOPF: International Tanker Owners Pollution Federation

IUCN: International Union for the Conservation of Nature

MDF: Mexican Department of Fisheries

MOU: Memorandum of Understanding

NCP: National Contingency Plan

NEBA: Net Environmental Benefits Analysis

NMFS: National Marine Fisheries Service

NOAA: National Oceanic and Atmospheric Administration

NRDA: Natural Resource Damage Assessment

PAH: Polycyclic (or Polynuclear) Aromatic Hydrocarbon

SCAT: Shoreline Cleanup Assessment Technique

SCL: Straight Carapace Length

SIMA: Spill Impact Mitigation Analysis

SLAR: Side-Looking Airborne Radar

SMART: Special Monitoring of Applied Response Techniques

SSC: Scientific Support Coordinator

STSSN: Sea Turtle Stranding and Salvage Network

TAP: Trajectory Analysis Planner

USCG: U.S. Coast Guard

USEPA: U.S. Environmental Protection Agency

USFWS: U.S. Fish and Wildlife Service

Appendix A: Memorandum of Understanding

MEMORANDUM OF UNDERSTANDING
DEFINING THE ROLES OF THE
U.S. FISH AND WILDLIFE SERVICE
AND THE
NATIONAL MARINE FISHERIES SERVICE
IN JOINT ADMINISTRATION OF
THE ENDANGERED SPECIES ACT OF 1973
AS TO SEA TURTLES

IN RECOGNITION of the current status of sea turtles and the mandate of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq*., ESA) to conserve and recover threatened and endangered species;

ACKNOWLEDGING that on July 18, 1977, the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS) (collectively referred to as the Services) entered into a Memorandum of Understanding titled *Defining the Roles of the U.S. Fish and Wildlife Service and the National Marine Fisheries Service in Joint Administration of the Endangered Species Act of 1973 as to Marine Turtles*;

IN ORDER TO facilitate orderly, effective administration of the ESA by the Services (as contemplated in paragraph 4 of the August 28, 1974, Memorandum of Understanding between FWS and NMFS regarding jurisdictional responsibilities and listing procedures under the ESA); and

RECOGNIZING that additional sea turtle species have been listed under the ESA and the Services' respective sea turtle program roles and responsibilities have expanded significantly since the July 18, 1977, Memorandum of Understanding;

THE SERVICES AGREE to the following division of roles and responsibilities for joint coordination and collaboration with respect to the conservation and recovery of sea turtles:

1. NMFS shall have jurisdiction for sea turtles, including parts and products, when in the marine environment ("marine environment" means oceans and seas, bays, estuaries, brackish or riparian water areas, and any other marine waters adjacent to the terrestrial environment) and for activities affecting sea turtles and their habitats in the marine environment, unless explicitly provided for otherwise within this Memorandum of Understanding (MOU).

2. FWS shall have jurisdiction for sea turtles, including parts and products, when in the terrestrial environment and for activities affecting sea turtles and their habitats in the terrestrial environment, unless explicitly provided for otherwise within this MOU. FWS shall also have jurisdiction for all imports and exports of sea turtles, including parts and products.

3. NMFS shall serve as the lead for and coordinator of the Sea Turtle Stranding and Salvage Network (STSSN) to attend to dead or distressed turtles in the marine environment or when washed ashore from the marine environment. Coordination by NMFS of the STSSN may include coordinating placement of stranded turtles at permitted rehabilitation facilities. Within its capacity, FWS shall provide assistance to the STSSN, including within the National Wildlife Refuge system. NMFS shall share STSSN information with FWS to promote the recovery and conservation of sea turtles.

4. FWS shall serve as the lead for and coordinator of permitted facilities holding sea turtles for rehabilitation or captive display. FWS shall share information with NMFS on captive sea turtles and coordinate with NMFS on guidelines and standards for such facilities.

5. All sea turtle petition findings, status reviews, species listings, recovery planning, and post-delisting monitoring activities under section 4 of the ESA shall be the joint responsibility of the Services. Critical habitat designations under section 4 of the ESA solely in the marine environment shall be the responsibility of NMFS, and critical habitat designations solely in the terrestrial environment shall be the responsibility of FWS. Critical habitat designations under section 4 of the ESA that include areas of both the marine and terrestrial environment may be

jointly designated by the Services. The Services shall coordinate with each other when either Service is considering designation of critical habitat for sea turtles.

6. The Services shall use their authorities under section 6 of the ESA to advance the conservation and recovery of sea turtles, as appropriate and as available funds allow. When either Service is developing, renewing, amending, or implementing a section 6 cooperative agreement that includes sea turtles, that Service shall coordinate with the other Service to ensure that such agreements promote the goal of conservation and recovery of sea turtles.

7. All consultations under section 7(a)(2) of the ESA for activities affecting sea turtles and their habitat in the terrestrial environment shall be the responsibility of FWS. All consultations under section 7(a)(2) of the ESA for activities affecting sea turtles and their habitat in the marine environment shall be the responsibility of NMFS. Joint biological opinions are often the most efficient way to implement the Services' authorities and provide clarity to action agencies and applicants. The Services shall coordinate with each other at the earliest opportunity on section 7 consultations for activities that may affect sea turtles in both the terrestrial and marine environments and shall decide whether a joint consultation is warranted. The Services shall exchange information annually with regard to incidental take of sea turtles authorized under section 7(a)(2) of the ESA. As envisioned in section 7(a)(l), the Services shall use other programs under their authorities, as appropriate, to support sea turtle recovery and conservation. As appropriate, to support sea turtle recovery, the Services shall coordinate on section 7(a)(l) conservation plans that have both marine and terrestrial components.

8. All rules or permits issued under sections 4(d) or 10 of the ESA for otherwise prohibited activities involving sea turtles and their habitat in the terrestrial environment shall be the responsibility of FWS. All rules or permits issued under sections 4(d) or 10 of the ESA for otherwise prohibited activities involving sea turtles and their habitat in the marine environment shall be the responsibility of NMFS. The Services shall provide each other an opportunity to review and comment on all rules or permits under consideration for issuance under section 4(d) or 10 of the ESA. The Services shall coordinate when a section 10(a)(1) conservation plan has

both marine and terrestrial components. The Services shall exchange information annually with regard to take and other activities involving sea turtles authorized under sections 4(d) and 10.

9. FWS shall coordinate with NMFS prior to issuing or denying any Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) permit or certificate involving the import, export, re-export, or introduction from the sea of sea turtles or their parts.

10. The Services shall coordinate with each other on international efforts to promote the global conservation and recovery of sea turtles and their habitats.

Law Enforcement

11. Both NMFS and FWS have authority to enforce the ESA's prohibitions with respect to sea turtles. The Services will collaborate on law enforcement activities, where joint enforcement efforts would be beneficial, to advance the conservation and recovery of sea turtles. The following paragraphs clarify primary areas of enforcement jurisdiction for NMFS and FWS. However, nothing shall preclude either Service from taking enforcement action outside their primary jurisdiction when such action is coordinated with the other Service.

11.1 NMFS shall have primary enforcement jurisdiction for violations in the marine environment, and for activities affecting sea turtles and their habitats in the marine environment, except as provided for in paragraphs 11.3 and 11.4.

11.2 FWS shall have primary enforcement jurisdiction for violations in the terrestrial environment, and for activities affecting sea turtles and their habitats in the terrestrial environment, except as provided for in paragraph 11.3 of this section.

11.3 NMFS and FWS will each have primary enforcement jurisdiction for violations occurring on lands and in waters administered by their respective agencies (i.e., National Wildlife Refuges, National Marine Sanctuaries).

11.4 FWS shall have primary enforcement jurisdiction for all imports and exports of sea turtles, including their parts and products, regardless of the means of conveyance.

General Provisions

12. Nothing in this MOU is intended to obligate any appropriated funds from any agency in conflict with any Federal law or regulation.

13. Should disagreement arise on the interpretation of the provisions of this MOU, or amendments or revisions thereto, that cannot be resolved at the operating level, the areas of disagreement shall be stated in writing by each Service and presented to the other Service for consideration. If agreement on interpretation is not reached within 30 days, the Services shall forward the written presentation of the disagreement to respective higher officials within their Department for appropriate resolution.

14. This MOU between FWS and NMFS will become effective by the signatures of the representing officials on the date of signature by the last Director/Assistant Administrator. The MOU will remain in effect until amended in writing or superseded by a new agreement.

15. Upon becoming effective, this MOU supersedes the July 18,1977, Memorandum o Understanding Defining the Roles of the U.S. Fish and Wildlife Service and the National Marine Fisheries Service in Joint Administration of the Endangered Species Act of 1973 as to Marine Turtles.

16. Nothing in this MOU is intended to conflict with the current authorities of the Services. If any terms of this MOU are inconsistent with existing directives of the Services, then those

portions of the agreement that are determined to be inconsistent may be considered to be invalid, but the remaining terms of this agreement not affected by inconsistency will remain in full force and effect. Nothing in this MOU provides a private right of action to other parties.

17. The terms of this MOU may be amended upon written agreement of both Services, either by amendment of this MOU in writing or by entering into a new agreement, whichever is deemed expedient by both Services.

18. Either of the Services may cancel this MOU upon 30 days written notice to the other Service.

[signature]	9/9/2015
Eileen Sobeck Assistant Administrator National Marine Fisheries Service	Date
[signature]	9.18.2015
Dan Ashe Director U.S. Fish and Wildlife Service	Date

Appendix B: Best Management Practices

Source: NOAA (2019)

Revised 22 Jan 2013

SECTION 7 FEDERAL AGENCY ACTION - ENDANGERED SPECIES ACT

MC 252 DWH Sec 7 Authorized Best Management Practices

For Louisiana

Applicable BMP Checklist for Individual Shoreline Treatment Recommendations

DATE: __________Branch/Division:____ STR # and Segments:__________________________

____

Role	Print Name	Signature	Date	Concur (Y/N)

1) In Daily 214s and on checklist, NRAs/READs should report: Notable migratory bird and threatened/endangered species activity in operational areas. Any logistical issues that interfere with implementation of specific BMPs. Instances of re-oiling in areas of completed shoreline treatments (Please advise if SCAT is required).

2) NOTE: Theses BMPs are developed as recommendations to avoid or minimize impacts to natural resources, including those protected by the Endangered Species Act of 1973. If these BMPs cannot be adhered to during oil removal operations an explanation or justification must be documented in the space provide at the end of this checklist. Please contact local or GCIMT Sec 7 Rep for clarification/guidance.

Applic-able Y or N/A	Correc-tive Action (x)	BMP #	BMP DESCRIPTION
		BMP 1	[MODIFIED] Watch for and avoid collisions with wildlife. Report all turtle sightings and all distressed or dead birds, sharks, rays, and marine mammals to the appropriate state hotline: ****See page 5 for phone #s**
		BMP 2	Retrieve injured/dead/oiled sea turtles using the turtle At-Sea Retrieval Protocol. **(N/A at this time unless changed by Sec 7)**
		BMP 3	[MODIFED] Avoid any vegetation, marsh soils, or peat with foot traffic/boats/equipment **by 10 feet** or contact **the Section 7 Coordinator/Liaison** to minimize impact. **Use existing travel corridors**.
		BMP 5	Maintain compliance with the Decontamination Plan where applicable.
		BMP 6	[MODIFIED] Cleanup operations during daylight hours are recommended. **If nightime operations are necessary: (1) confine operations to landward side of the intertidal zone; and, (2) Year Round, follow ENV0009: *Minimizing Impacts to Wildlife during Nighttime Cleanup Operations.* Avoid night-time activities in identified exclusion areas to allow longer periods without disturbance to wildlife and to minimize vehicle damage within optimal habitat.**

		BMP 7	[MODIFIED] **From 1 May through 31 October***, observe a 10 foot buffer from marked sea turtle nests. If a nest area is contaminated/oiled, contact appropriate State for further instructions**: **See page 5 for phone #s**
		BMP 8	[MODIFIED] Utilize existing access/egress areas and roadways. **UTVs should remain within the established travel path when possible, to minimize beach topographic alterations.**
		BMP 9	[MODIFED] **From 1 May through 31 October***, verify sea turtle nesting activities with agency experts and begin onshore cleanup operations during daylight hours after nesting surveys/conservation activities are completed. **If nighttime cleanup operations will be conducted, Wildlife Observers must be present**.
		BMP 10	[MODIFIED] Use low-pressure tire **(10 psi)** vehicles (e.g. ATVs, Gators) or contact a qualified biologist to minimize impact.
		BMP 11	[MODIFIED] **Year round**, if feasible and per appropriate guidance, restore beach topography, if altered, to natural beach profile by 2000 hours each day.
		BMP 12	Minimize removal of clean sediments and organic matter.
		BMP 13	[MODIFIED] Avoid hovering or landing aircraft near posted bird sites **and dunes**.
		BMP 14	If skimming, avoid skimming sargassum that is not oiled or is only very lightly oiled. **(N/A after 14 NOV 2010)**
		BMP 15	If a sea turtle is observed trapped or entangled in a boom(s), open the boom carefully until the animal leaves on its own.
		BMP 16	[MODIFIED] **Install,** monitor, **or remove** under water equipment/booms to prevent fish/wildlife entrapment.
		BMP 17	Do not block major egress points in channels, rivers, passes, and bays.
		BMP 19	Sea turtle observer on the ignition vessel will monitor 3 areas prior to the burn… **(N/A after 14 NOV 2010)**
		BMP 20	A survey should be conducted in the burn area after the burn is complete… **(N/A after 14 NOV 2010)**
		BMP 21	Avoid burning unoiled/lightly oiled Sargassum . **(N/A after 14 NOV 2010)**
		BMP 22	No flights below 500 feet over wildlife refuges, management areas, bird rookeries, or National Parks.
		BMP 23	No dispersant application within 2 nautical miles of sighted marine mammals/sea turtles. **(N/A after 14 NOV 2010)**
		BMP 24	Turtle excluder devices (TEDs) should be installed on all trawl nets.
		BMP 25	[MODIFED] Staging areas and waste collection areas should be examined prior to set up and should be located to avoid beaches, **dunes**, **inlets or ephemeral tidal pools**, scrub, and other vegetated areas. **Contact the Section 7 Coordinator/Liaison if assistance is needed.**

		BMP 26	[MODIFIED] All heavy equipment should be as low on the beach as possible unless oiled and avoid the high tide/wrack line (dead organic matter - seaweed, grasses, driftwood) while conducting cleanup activities and traveling to and from locations. If the wrack line must be crossed by equipment or vehicles, a READ, NRA, or biologist may rake the wrack out of the way to establish a travel corridor for crossing.
		BMP 27	Activities that may require removal of forested and shrub or scrub habitat should be minimized.
		BMP 28	If bears are observed, contact Env. Unit: 504-335-0905 or 504-335-0911
		BMP 29	Remove all trash or anything that would attract wildlife to work areas on a daily basis.
		BMP 30	If a sea turtle is spotted, maintain at least 200 feet between the turtle and any beach clean-up activities.
		BMP 31	Stakes or flagging should not be removed or destroyed anywhere on the beach.
		BMP 32	For net recovery of tar balls, a maximum allowable tow time of 30 minutes. After 30 minutes, check the net for any live or dead sea turtles.
		BMP 33	All vessels must be equipped with the necessary equipment (dip nets, holding containers, towels, etc.) to capture and hold sea turtles aboard the vessel. **(N/A after 14 NOV 2010)**
		BMP 34	Resuscitate any live, unresponsive sea turtles according to the attached sea turtle resuscitation guidelines.
		BMP 35	Safely release uninjured and unoiled sea turtles over the stern of the boat, when gear is not in use, the engine is in neutral, and in areas where they are unlikely to be recaptured or injured by vessels. **(N/A after 14 NOV 2010)**
		BMP 36	To reduce the possibility of bottlenose dolphin entanglement in the lazyline, use a stiffer line such as a crab lay.
		BMP 37	[NEW] NRAs or READs should check work corridor ahead of working equipment for evidence of sea turtles, shorebirds, and beach mice. If conducting nighttime operations, initial surveys should be done on foot, but UTVs/ATVs may be used if needed, to adequately check in front of working equipment after the corridor has been cleared.
		BMP 38	Sea turtle crawls should not be impacted until nest sites have been appropriately documented.
		BMP 39	[MODIFIED] Avoid the dunes, both vegetated and non-vegetated. Establish a buffer zone, with flagging if necessary, from the toe of the slope of the dune to a distance of 10 feet. Where vegetation extends off the dune onto the beach, the buffer should extend 10 feet from the vegetation. Mechanical activity (equipment, UTV, etc.) should not occur in the buffer or on the dune. Contact the Sec 7 Coordinator/Liaison for sand
		BMP 40	All vessels shall operate at "no wake/idle" speed at all times while in water where the draft of the vessel provides less than a four-foot clearance from the bottom. All vessels shall follow deep-water routes whenever possible.

		BMP 41	Land or stage boats to avoid crushing the vegetation.
		BMP 42	Avoid scouring and prop-scarring submerged aquatic vegetation (e.g., seagrass).
		BMP 43	[NEW] READs, NRAs, WOs, or biologists should accompany all cleanup crews (both daytime and nightime operations) in appropriate numbers to ensure BMPs are implemented properly. Contact the section 7 **Coordinator/Liaison** for recommendations on appropriate numbers.
		BMP 44	[NEW] If nighttime operations are required, Year Round shielded headlamps must be used, in addition appropriate red filters must be used 1 May through 31 October*.
		BMP 45	[NEW] Minimize disturbance to bayside flats by reducing the amount of cleanup comparable to the amount of tarball accumulation. For example, areas with minimal tarballs might only require a cleanup once every two
		BMP 46	[NEW] If sporadic tarballs are seen in the dune buffer zone or on the dune, they may be removed by a single person or by a crew of up to three individuals using small hand tools, working from the buffer zone. Avoid walking, standing, sitting, or other human intrusion on the dunes. If more than sporadic oil residues are noted in the dunes, contact the Section 7
		BMP 47	[NEW] The operational area should be surveyed by an NRA or READ for the presence of piping plovers or optimal habitat features and documented on the BMP checklist and 214. Optimal habitat includes inlets, bayside mud flats, tidal pools and wrack lines. When piping plovers are identified, vehicle and foot traffic should not occur within 150 feet from the birds, or 10 feet from optimal habitat features when escorted by a NRA or READ. If day or night travel through exclusion zones is necessary, vehicles should follow existing/established travel lanes and maintain slow speeds
		BMP 48	[NEW] If a Bald eagle nest is discovered, all activities should avoid the nest by 660 feet unless the nest is protected by a vegetated buffer, then the avoidance distance is 330 feet. If a Bald eagle nest is discovered, the "National Bald Eagle Management Guidelines" should be followed in order to not disturb the eagles during any nesting, feeding or roosting activities. These guidelines are available at: http://www.fws.gov/migratorybirds/baldeagle.htm.
		BMP 49	[NEW] Surveys for migratory bird nests should be implemented beginning in February in Florida and Louisiana and April for all other areas. When nesting areas are discovered, these areas and historically used areas should be roped to prevent cleanup activities from encroaching into nesting areas and rookeries. Cleanup in the roped area should be avoided.
		BMP 50	[NEW] Avoid removing the wrack line. Manually remove tarballs from the primary wrack line. If wrack is covering subsurface oil that must be cleaned, the wrack can be manually raked out of the way and then put back once the oil is removed.
		BMP 51	Follow the *"Avoidance of Nesting Birds and Piping Plovers During Shoreline Cleanup on Beaches"* to protect piping plovers and their critical habitat.
		BMP 52	**[NEW]** Avoid posted/marked or other known bird nesting areas and rookeries and minimize activities in critical habitat areas for Endangered Species. All land and water crafts, when operated near these areas shall

			be controlled to minimize noise and speed. Air Boats shall not be used unless all other reasonable means have been tried and then pre-approval must be obtained from the Trustee/Landowner(s). If it is determined that an Air Boat is the only viable means of transportation, then a distance of 1000 feet should be maintained from critical habitats, marshes, wetlands, rookeries, and/or other high bird use areas.
			*** All seasonal restrictions listed above may be adjusted by the section 7 Coordinator/Liaison based upon the likelihood of species presence.**
			**** For all whales and dolphins in the Gulf:** 1-877-WHALE-HELP or 1-877-942-5343. Manatees in Alabama, Mississippi, and Louisiana: 1-904-731-3079. Sea Turtles in Louisiana: 1-337-962-7092. Birds in Louisiana: 1-225-954-9883 or 1-225-698-3168

Comments / Corrective Actions:
BMP 51- determine if any piping plover are in within 150 feet of the operational area, note on the bmp checklist or 214 the number of individuals, distance from the operational area, their activities, and gently encourage the birds to move away from the operational area. Once the birds have moved, note any behaviors including normal or stress behaviors and the activities that the birds resume. If more than five individuals are present in the travel corridor or an area for deep cleaning, contact the Deepwater Horizon Virtual section 7 liaison (holly_herod@fws.gov or 404-679-7089) for additional instructions.

In Daily 214s (Unit Logs) and on checklist, NRAs/READs should report:
- **notable migratory bird and threatened/endangered species activity in operational areas.**
- **any logistical issues that interfere with implementation of specific BMPs.**
- **instances of re-oiling in areas of completed shoreline treatments. Please advise if SCAT is required.**

If you have questions regarding implementation of BMPs, contact your Section 7 Liaison or Resources at 404-679-7089 or FW4Section7OilSpill@fws.gov

Reporting Instructions: Before Operations conducted, **NRAs and READs** must Review all Applicable BMP's for the specific STR indicated by Sec 7 on this form; During and/or After Operations conducted, Fill out BMP Implementation Checklist and document any divergence from the BMP's that occurred.

NRAs/READs E-mail Completed BMP Implementation Checklist to: **GCIMT**Documentation@bp.com ; FW4DisasterDocumentation@fws.gov ; FW4Section7OilSpill@fws.gov ; NMFS.ser.mobile.reports@noaa.gov and **E-mail Daily 214s(Unit Logs)to your NRA/READ Team Lead.**

NRA/READ Team Leads append all team member Daily 214s to one **E-mail** and send to: **GCIMT**Documentation@bp.com ; FW4DisasterDocumentation@fws.gov ; FW4Section7OilSpill@fws.gov ; MC252_GCIMTSIT@bp.com ; NMFS.ser.mobile.reports@noaa.gov

Appendix C: Examples of Best Management Practices to Protect Sea Turtles During Response Operations

Source: NOAA (2019)

Best management practices to protect sea turtles during in-situ burn operations

Sea turtles can be adversely affected during corralling/booming of oil and oiled floating *Sargassum* seaweed or other converged material. Turtles may also be in the oil whether or not there is *Sargassum* present. The concern with in-situ burning is that any live turtles in the boomed oil and/or oiled *Sargassum* or other converged material could potentially be burned when the oil is ignited.

Best management practices to reduce in-situ burns impacts to sea turtles

1. Collect all live and dead turtles according to the Retrieval of Oiled, Dead, or Debilitated Sea Turtles Protocol whenever possible.
2. The best possible mitigation measure is to have turtle rescue vessels (with trained rescue personnel, if available) accompany the burn taskforce into the scheduled burn area and to search all material to rescue turtles prior to burning, while oil is being boomed or otherwise is awaiting burning. If this is not possible then the following should be considered:
3. Send turtle rescue vessels (with trained rescue personnel, if available) into the next day's projected burn area to search for and rescue turtles. Feasibility will depend on the size of the projected area and whether material has already been boomed or otherwise collected.
4. Have a trained observer (if available) or a crew member dedicated to looking for sea turtles (as well as marine mammals and other taxa) during corralling operations and record each sighting event, including GPS location, species (if known), description of encounter on the Sea Turtle Observation Form.
5. Have a trained observer on board the ignition or support vessel (or other small vessel carrying the observer) to visually inspect each portion prior to ignition. Note that it may be difficult to see turtles in thick corralled oil, so multiple observers, searching from different angles, would be ideal.
6. Immediately report any wildlife within the burn area to [INSERT CONTACT INFORMATION].

7. If possible, all *Sargassum* that is not-oiled or is only very lightly oiled should be avoided.
8. If possible, a survey should be conducted in the burn area after the burn is complete and all dead sea turtles should be counted and collected, or at least photographed.

Best management practices to protect sea turtles during skimming operations

Use of oil skimmers can adversely affect sea turtles through possible capture and/or entrainment.

Best management practices to reduce skimmer impacts to sea turtles

1. Collect all live and dead turtles according to the Retrieval of Oiled, Dead, or Debilitated Sea Turtles Protocol whenever possible.
2. The best possible mitigation measure is to have turtle rescue vessels (with trained rescue personnel, if available) accompany the skimming taskforce to search all material to rescue turtles prior to skimming. If this is not possible then the following should be considered:
3. Send turtle rescue vessels (with trained rescue personnel, if available) into the next day's projected area to search for and rescue turtles. Feasibility will depend on the size of the projected area and whether material has already been boomed or otherwise collected.
4. Have a trained observer (if available) or a crew member dedicated to looking for sea turtles (as well as marine mammals and other taxa) during skimming operations and record each sighting event, including GPS location, species (if known), description of encounter on the Sea Turtle Observation Form.
5. Immediately report any sea turtles to [INSERT CONTACT INFORMATION].
6. If possible, all *Sargassum* that is not-oiled or is only very lightly oiled should be avoided.

Appendix D: Temporal presence of different life stages (adults, juveniles, hatchlings) for each species in each U.S. region

Source: NOAA (2019)

Blue shading indicates in-water presence, pink shading indicates the additional presence of breeding and nesting turtles. Darker colors indicate periods of higher concentrations of turtles, lighter shading reflects anticipated lower concentrations, and "NP" indicates absence. Species that are present in U.S. territorial waters but do not nest in U.S. territories belong to breeding populations whose nesting sites are outside of the U.S. (e.g., hawksbills and leatherbacks in the northern Gulf of Mexico nest in the Wider Caribbean region, leatherbacks present in the East Pacific nest in Indonesia, olive ridleys present in the Pacific nest in Mexico and Central America).

Region	Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
NW Atlantic (New York to Maine)	Kemp's ridleys	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles
	Loggerheads	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles
	Green turtles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles
	Leatherbacks	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles
	Hawksbills	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles
	Olive ridleys	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
Mid-Atlantic (Delaware to Virginia)	Kemp's ridleys	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles
	Loggerheads	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles	Adults Juveniles
	Green turtles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles
	Leatherbacks	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles
	Hawksbills	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles	Juveniles
	Olive ridleys	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP

Blue shading indicates in-water presence, pink shading indicates the additional presence of breeding and nesting turtles. Darker colors indicate periods of higher concentrations of turtles, lighter shading reflects anticipated lower concentrations, and "NP" indicates absence. Species that are present in U.S. territorial waters but do not nest in U.S. territories belong to breeding populations whose nesting sites are outside of the U.S. (e.g., hawksbills and leatherbacks in the northern Gulf of Mexico nest in the Wider Caribbean region, leatherbacks present in the East Pacific nest in Indonesia, olive ridleys present in the Pacific nest in Mexico and Central America).

Region	Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
SW Atlantic (North Carolina to Florida)	Kemp's ridleys	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles	Adults Juveniles
	Loggerheads	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles	Adults Juveniles
	Green turtles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles	Adults Juveniles
	Leatherbacks	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles	Adults Juveniles	Adults Juveniles
	Hawksbills	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles	Adults Juveniles
	Olive ridleys	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
Gulf of Mexico/ Northern Caribbean (U.S. EEZ)	Kemp's ridleys	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles	Adults Juveniles
	Loggerheads	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles	Adults Juveniles
	Green turtles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles
	Leatherbacks	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles
	Hawksbills	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles	Adults Juveniles
	Olive ridleys	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP

Blue shading indicates in-water presence, pink shading indicates the additional presence of breeding and nesting turtles. Darker colors indicate periods of higher concentrations of turtles, lighter shading reflects anticipated lower concentrations, and "NP" indicates absence. Species that are present in U.S. territorial waters but do not nest in U.S. territories belong to breeding populations whose nesting sites are outside of the U.S. (e.g., hawksbills and leatherbacks in the northern Gulf of Mexico nest in the Wider Caribbean region, leatherbacks present in the East Pacific nest in Indonesia, olive ridleys present in the Pacific nest in Mexico and Central America).

Region	Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
East Pacific (contiguous U.S. West Coast)	Kemp's ridleys	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
	Loggerheads	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles
	Green turtles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles
	Leatherbacks	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles
	Hawksbills*	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles
	Olive ridleys	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles
Central North Pacific (e.g., Hawaii, outlying islands, and connecting high seas areas)	Kemp's ridleys	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
	Loggerheads	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles
	Green turtles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles	Adults Juveniles
	Leatherbacks	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles
	Hawksbills	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings	Adults Juveniles Hatchlings
	Olive ridleys	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles	Adults Juveniles

U.S. DEPARTMENT OF COMMERCE
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