Chapter 6 Case Studies of Spills that Threaten Sea Turtles

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Key Points

- Sea turtles have been at risk of exposure in many oil spills, particularly in the Caribbean and Gulf of Mexico.
- There are surprisingly few reports of sea turtles or their nest sites being oiled or injured during the response to an oil spill.
- In recent years the typical incident threatening sea turtles is not from crude oil from a tanker, but rather from a fuel oil spill from grounded fishing vessels or cargo ships.
- Despite the potential for oil spills to harm sea turtles, actual incidents in which impacts have been documented are rare.
- Absence of documentation does not imply absence of effect, but is due to the low probability of observing and recovering oiled turtles.
- Most reports of sea turtle impacts are from Florida or the Caribbean.

Past and Present Spills that Threaten Sea Turtles

Planning response activities for spills that threaten sea turtles may be improved by understanding past spills and response to them. How many incidents occurred that threatened sea turtles? What kinds of accidents were most threatening? What products were involved? How many turtles were exposed, threatened, or affected? How did the response minimize injury to sea turtles? By studying and understanding the answers to these questions and considering them "lessons learned," we can improve preparedness and response methods for spills affecting sea turtle habitats.

To answer these questions, NOAA HAZMAT reviewed two sources of data and information on past spills and incidents in ocean areas occupied by sea turtles (accessible on the NOAA HAZMAT website at http://response.restoration.noaa.gov), along with three international case histories that occurred in recent years, but which are not in these databases.

HAZMAT - NOAA Hazardous Materials Response Division

1. The NOAA HAZMAT Historical Incidents Database contains reports and images from about 1,000 oil spills and chemical accidents from 1977 to 2001. It includes mostly U.S. incidents, some significant international incidents, and incidents in which a spill was averted (no oil spilled), but which at the time posed a threat. It does not include inland events that occurred away from the coast or navigable waterways.

2. The 1992 NOAA HAZMAT Case History document includes information on 110 "significant" spills that occurred worldwide between 1967 and 1991. To these we added three additional international case histories that occurred in recent years, but which are not in these databases. Case histories summarized in this chapter are ones that exceeded 4 million gallons (gal) total (419,000 gal in U.S. waters); involved the use of dispersants; involved bioremediation; or involved severe environmental impacts (more than 500 birds and 100 mammals killed, over a mile of intertidal zone smothered, fisheries closed, etc.).

Both information sources were searched for spills that may have threatened sea turtles or their nesting sites and habitat. A word of caution. First, the information is not comprehensive, that is, not all spills and potential spills were reported. Therefore, interpretation of trends and frequencies need to be taken with a grain of salt. Second, these are mainly response reports and may not contain additional follow-up information, such as that appearing in the literature or in government or industry damage assessment and restoration reports many years after the initial spill response.

The Big Picture: 1967–2001

The years 1967 to 2001 included 126 incidents. Despite a long history of major oil spills, the case history files indicate that few incidents reported oiling, contaminating, or killing of sea turtles or oiling of nesting sites. Either turtles were rarely impacted or the historical files are not sufficiently complete or detailed to document injuries, protection strategies, or rehabilitations.

Number of Incidents

Of the incidents documented,104 mentioned sea turtles, and 91 incident reports suggest marine turtles may have been at risk. Oil or fuel actually spilled in only 67 of the 91 cases. Of these, oiled, injured, or dead sea turtles were reported in only seven cases: *Witwater*, *Alvenus*, Trague Beach (Guam), Gulf War, *Vista Bella*, *Barge Bouchard*, and *Barge Morris J. Berman*.

Locations of Spills

Of 110 incidents reported in the1992 NOAA HAZMAT Case History Report, 43 occurred in tropical and subtropical waters, approximately 30° N to 30° S, half of which were also reported in the historical incidents database. Only four (*Alvenus, Peck Slip, St. Peter,* and Virgin Islands Water and Power), explicitly listed turtles or nesting sites as resources at risk.

Volume Spilled

About 770 million gal of oil and fuel were spilled, most of it by the three largest and longest marine spills in history:

- the 1991 Gulf War spill in Kuwait and Saudi Arabia (252 million to 335 million gal);
- the 1979 Ixtoc I platform blowout in Campeche Bay, Gulf of Mexico, (147 million gal); and
- the 1983 Norwuz spill in the Arabian Gulf (79 million gal).[1]

Median volume of all tropical spills from 1967 to 2001 was 38,900 gal. Excluding the three mega-spills, the median volume was relatively unchanged (34,985 gal). From the 1960s through the 1980s, most larger oil spills were from shore facilities, damaged tankers, and oil platform accidents. Several nearshore spills resulted from vessel groundings.

Materials Spilled

Many potential or actual incidents involved two or more oil products. Of 121 separate (specific) products, only 42 (35 percent) were crude oils; the remaining 79 products (65 percent) were fuels, lube oils, and other refined products.

Response Methods

Responses mainly involved conventional methods for protection (booming) and removal (skimming, shoreline cleanup). Dispersants were used or considered on 34 spills—some successfully, others with little or no success. Most dispersants were used on international (non-U.S.) spills, but seven were in Puerto Rico, four in Texas, three in Louisiana, and one in New Jersey. There is no information about the extent to which oil or dispersants affected sea turtles.

The Past Decade (1992–2001)

Large crude oil spills decreased in frequency and volume in the last decade (NRC 2002). Seventy-three actual or potential spills occurred in tropical areas or at times when turtles were indicated as resources at risk.

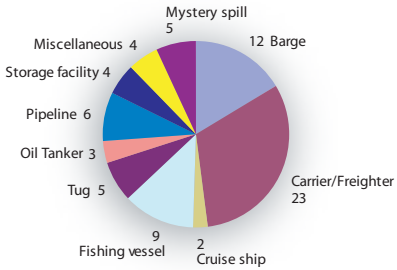
Spill Locations

Geographically, most incidents occurred along the Gulf of Mexico (26) and Florida's Atlantic coast (9). Another 16 occured in the Caribbean (13 in Puerto Rico alone), 12 in Atlantic states north of Florida, 9 in the Pacific, and 1 in South America. Of these 73 cases:

- Sea turtles and their nest sites or habitats were noted at risk during response in 40 (55 percent) cases.

- Only three (4 percent) occurred where turtles or nest sites were noted as oiled or otherwise protected or rehabilitated.
- Fifty-two (71 percent) resulted in actual spills.
- Fifty-four incidents (74 percent) were from vessels; 13 (18 percent) were from pipelines, platforms, or docks.

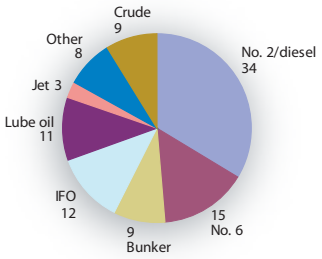
Figure 6.1 Sources of oil spilled in tropical areas, 1992–2001.



Volume Spilled

The total volume spilled was 3.3 million gal: 2.5 million gal from vessels and 738,400 gal from stationary sources. The median incident release (including averted spills) was only about 3000 gal, a ten-fold decrease from the medians in the 34 years from 1967 through 2001. The median volume from mobile sources was 4,032 gal, ranging from 126 to 287,185 gal; from stationary sources, the median was 12,600 gal, ranging from 42 to 284,465 gal.

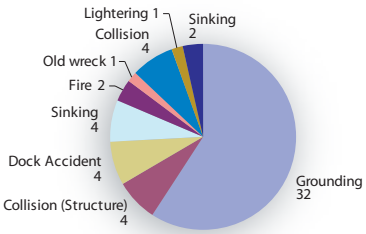
Figure 6.2 Types of oil and fuels spilled in tropical incidents, 1992–2001.



Sources

Among the mobile sources (Figure 6.1), 23 (43 percent) were from freighters (carriers), 12 (22 percent) from barges, 9 (17 percent) from fishing boats, and 5 (9 percent) from tugboats. Only 3 incidents (6 percent) involved tankers. Among stationary sources, 6 spills (46 percent) were from pipeline breaks, and 4 (31 percent) were from storage facilities.

Figure 6.3 Causes of incidents in tropical areas, 1992–2001.



Material Spilled

As shown in Figure 6.2, the most frequent material was diesel or No. 2 fuel oil (34 cases), followed by No. 6 fuel (15), intermediate fuel oils (12), lube oil (11), Bunker C (9), crude oil (9), other refined products (8), and jet fuel (3). Thus most spills threatening turtles during the past decade involved refined products (89 percent), not crude oil. Twenty of the 54 incidents spilled more than one product for a total of 101 product spills.

Cause of Spills

Fifty-four spills were from mobile sources (vessels), 13 from stationary sources, and 6 from other sources.

Of the spills from mobile sources (Figure 6.3), 32 (60 percent) were from vessel groundings, and the rest from collisions, dock accidents, sinkings, fires, and lightering. Of all spills in tropical waters between 1992 and 2001, most (85 percent) occurred from the shoreline or very close to shore.

Response Methods

Responses to most spills involved traditional methods of containment (boom) and removal (skimming, shoreline cleanup). Dispersants were used or considered on 12 spills; spills were averted in 3 incidents. Three dispersed spills occurred in Puerto Rico, 2 in Texas, and 1 each occurred at St. Eustatius, Galapagos Islands; New Jersey; and Punta del Este, Uruguay. There is no information about the extent to which oil or dispersants affected sea turtles.

Selected Case Studies

Although many oil spills have occurred in areas populated by sea turtles, cases of large numbers of turtles directly impacted by a spill are very rare. This may be due, in part, to the fact that sea turtles have wide ranges and usually are highly dispersed. In assessing impacts from past spills, it is important to recognize that the effects of oil on sea turtles probably are not well-reflected by the few reported observations of oiled turtles. Documenting the number of turtles affected by an oil spill is difficult. Many impacted turtles are unlikely to be observed or recovered. Furthermore, most reports of spill-related sea turtle impacts are anecdotal, and the cause of death is usually poorly documented. Oil spills where impacts to sea turtles have been documented are summarized briefly below.[2]

1968 Oil Tanker SS *Witwater*

The oil tanker SS *Witwater* ruptured in heavy seas off the Carribean coast of Panama on 13 December 1968, spilling over 588,000 gal of diesel and Bunker C oils approximately 3.7 km northeast of Galeta Island (NOAA 1992). The oil eventually washed 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 suptralittoral zone up to 2 m above mean high-tide level. Red and black mangrove trees were severely oiled, killing most red mangrove seedlings, the algal community, and invertebrates. Researchers also observed dead and dying young sea turtles on oiled mangrove beaches two months after the spill, however the exact cause of death was not determined (Rutzler and Sterrer 1970).

1979 Ixtoc I Well Blowout

On 3 June 1979, the Ixtoc I, an offshore exploratory oil well located 80 km off Ciudad del Carmen, Mexico, suffered a massive blowout of its wellhead and began releasing oil into the Bay of Campeche. Thousands of barrels of oil were released daily until the spill was brought under control in late March 1980 (Hooper 1981). The oil drifted north, eventually impacting portions of the Mexican 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.

The spill threatened a primary nesting beach of the Atlantic Kemp's ridley sea turtle near Rancho Nuevo, Tamaulipas, Mexico. The nests were aggregated in arribadas of thousands of females. In Mexico, hatching begins in mid-June, and the hatchlings continue to emerge until mid-September, then swim west and north during the next two months.

MDF - Mexican Department of Fisheries.

The Ixtoc I blowout occurred after nesting but before all hatchlings had migrated across the beach to the water. 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 (Golob and McShea 1980).

More than 200 gal of oil were reportedly recovered during cleanup of the beach and lagoons near Rancho Nuevo (Golob and McShea 1980), but oil was still evident on the beach during the nesting season the following year (Fritts and McGehee 1982). Eventually, oil impacted over 257 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, tarmats, or mousse. Environmentally sensitive, economically important beaches in Texas were cleaned daily using rakes and shovels rather than heavy equipment, which removes too much sand. An estimated 7,646 cubic meters of oiled 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 (Lutcavage et al. 1997). 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 (Hall et al. 1983; Hooper 1981). Rabalais and Rabalais (1980) reported that 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 young 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. Autopsies found that while external oil was present on all three turtles (oil was found in the mouth and esophagus and all three had evidence of petroleum hydrocarbons in lung, esophageal, intestinal, liver, and kidney tissues), but the cause of death could not be determined conclusively (Hall et al. 1983). The amount of oil present was considered unlikely to have prevented normal movement or have been otherwise fatal. Two of the turtles were in poor condition, but had no apparent oil-caused lesions. Hall et al. reported that tissue chemical analysis indicated that oil exposure had been chronic, and it was this prolonged exposure that may have caused the turtles' poor body 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 affecting orientation cues or hatching success, there is no indication this oil spill significantly adversely affected Kemp's ridley sea turtles (Delikat 1980 and 1981). This conclusion is supported by the results of the study by Fritts and McGehee (1982), discussed in Chapter 4.

1983 Nowruz Oil Spill

Between January and October 1983, an estimated 42 million gal of oil were spilled into the Persian Gulf, primarily from several spills associated with the Iran-Iraq War (Miller 1989). In January 1983, oil began to discharge from a well in the Nowruz oil field, in Iranian territorial waters. Two other platforms damaged by military action in March 1983 contributed to the spill, as did other smaller spills and ballast pumping. Large areas of sheen, tarballs, and weathered oil rafts were reported in the Persian Gulf during April, May, and early June. Oil coated rocky shorelines, sandy beaches of offshore islands, and the Saudi Arabian mainland. On sandy 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 Persian Gulf coast, including over 56 green and hawksbill sea turtles. Only a portion of the coastline was monitored, so the number of turtles killed may have been higher. Some accounts indicated as many as 180 hawksbill turtles were killed off the islands of Jana and Karan (Lutcavage et al. 1997). Burchard (as cited in Miller 1989) estimated that over 500 sea turtles of both species were killed, representing nearly total annihilation of the hawksbill population and a major portion of the green turtle population. The direct and indirect impacts to sea turtles from oil on nesting beaches and other sea turtle habitat remains unknown but Miller (1989) concluded the impact likely was severe.

1984 Oil Tanker *Alvenus*

The oil tanker *Alvenus* grounded in the Calcasieu River bar channel, 18 km southeast of Cameron, Louisiana, on 30 July 1984. The hull was ruptured, spilling approximately 2.7 million gal of medium and heavy Venezuelan crude oils. Rough weather hampered offshore recovery efforts, the oil moved slowly westward, eventually washing ashore near High Island, along the Bolivar Peninsula, and in Galveston Bay, Texas. Shoreline cleanup techniques included using road graders to move beached oil above the high-tide zone. During the response, one oiled sea turtle was cleaned and released (NOAA 1992).

1991 Gulf War

Approximately 252 million to 335 million gal of oil were 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 (Al-Majed et al. 2000). An estimated 335 million gal spilled directly into the Persian Gulf, forming a 1,554-square-km oil slick. Tarmats up to 30 cm thick formed on impacted beaches between Safaniya and Abu Ali Island, Saudi Arabia. Cleanup operations recovered over 42 million gal by April 1991 (NOAA 1992).

Estimates of the number of sea turtles killed by the oil spilled during the Gulf War range from tens to hundreds, but are not well-documented (Lutcavage et al. 1997). One stranded green turtle that was recovered and necropsied contained over 4,000 ppm of oil in its liver and 310 ppm in its stomach, but no external indication of oil (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 Persian Gulf must be substantially reduced if sea turtle populations throughout the region are to survive at their current levels" (Miller et al. 1989).

1991 Barge *Vista Bella*

On 6 March 1991, the Trinidad-registered barge *Vista Bella* sank in 600 m of water about 19.3 km northeast of Nevis Island in the eastern Caribbean, after a towing cable snapped. The barge carried around 560,000 gal of No. 6 fuel oil. By March 13, oil, tarballs, and oiled debris had washed ashore on sea turtle nesting beaches on the north shore of St. Kitts, including Conaree. By March 21, tarballs and tar patties began appearing on St. John, and tarballs washed ashore on St. Thomas, St. Croix, Culebra, Vieques, and the main island of Puerto Rico shortly thereafter. Several beaches in the British Virgin Islands were oiled, and one oiled hawksbill attributed to the spill was recovered near Guayama, Puerto

Rico (Eckert et al. 1992; Eckert and Honebrink 1992). During this incident, the French Navy applied the dispersant Finasol OSR7, but details of the application are sketchy.

Surf-washing - **a technique for removing oil from deposited beach material in which oil or oiled sediments are moved to a tidal elevation where they may be exposed to higher levels of wave energy (i.e., "washed"). The reworking of surface or subsurface sediments accelerates natural degradation processes.**

1993 Barge *Bouchard B155*

On 10 August 1993, a freighter and two tugs collided in Egmont Channel in lower Tampa Bay, Florida. During the collision, the barge *Bouchard B155* released 336,000 gal of heavy No. 6 fuel oil from one of its cargo holds. By August 15, most of the floating oil had washed ashore and coated approximately 23 km of sandy beach, several mangrove islands, and seawalls. On some sandy beaches, stranded 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 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 beaches in 1.8 to 6 m of water and inside the entrance to Boca Ciega Bay at John's Pass and Blind Pass.

Figure 6.4 A nesting beach oiled after the 1993 Bouchard B155 *spill in Tampa Bay, Florida. Photo courtesy of Dr. Anne Meylan, Florida Marine Research Institute.*

Cleanup of impacted sandy 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, was used for sand removal and surf-washing. Final beach grooming was done with graders and disking equipment, normally to a depth of 30 cm. Oil around the mangrove islands was vacuumed using grounded barges staged in shallow sand flats, followed by manual removal within the mangrove edges. Submerged oil patties and tarballs were removed manually. Attempts were made to vacuum submerged oil mats west of Eleanor Island in Boca Ciega Bay.

Sea turtle nesting beaches and foraging areas were oiled, then disturbed by cleanup operations (Figure 6.4). Loggerhead, Kemp's ridley, green, and hawksbill turtles occur in the affected area. The Florida Department of Environmental Protection et al. (1997) summarized sea turtle impacts. Loggerhead sea turtles, the most common, were impacted most severely: 4 hatchlings were recovered dead, and 12 live hatchlings were recovered oiled and were cleaned, rehabilitated, and released. Of these 12, 3 were oiled, 2 were trapped behind booms with oil, and 7 had no trace of oil but were disoriented by lights associated with the response (A. Meylan 2002[3]). One oiled, live juvenile green turtle was recovered offshore in an oiled windrow and was cleaned and released (Figure 6.5). 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 subsequently had a lower than normal hatching success rate (5 percent of eggs, compared to 50 to 90 percent normally), and 29 hatched during the spill and response. One unmarked nest was run over

Figure 6.5 A juvenile green turtle oiled during the 1993 Bouchard B155 *spill in Tampa Bay, Florida. Photo courtesy of Dr. Anne Meylan, Florida Marine Research Institute.*

by a bulldozer, crushing 5 eggs; the remaining eggs were transplanted but less than a third hatched. Approximately 1,530 loggerhead hatchlings from 23 of the 29 nests that hatched 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. In January 2000, several years after the spill, submerged oil entrained in bottom sediments of sheltered coastal inlets was uncovered 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 during 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. A plan was developed to remove the submerged oil in Blind Pass and John's Pass in conjunction with the dredging and beach renourishment program. Oil was to be removed from the sand prior to placement on beaches as part of the beach renourishment operations. Turtle nesting beaches were monitored and surveyed to ensure that no oil was deposited as a result of these operations.

1994 Barge *Morris J. Berman*

On 7 January 1994, the tank barge *Morris J. Berman* grounded on hard rocky and coral bottom in the surf zone 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 37 km northeast of San Juan, and sunk.

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 a convergence zone concentrated debris and oil was released when the barge was scuttled. Some oil was buried,

forming oily sand layers, and some oil was 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 resources 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 continuous oil deposits were cleaned by manual removal, taking precautions to remove a minimal amount of clean sand. Heavy equipment, including backhoes and front-end loaders, was used to remove large areas of heavily oiled sand and buried tarmats. 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 manually by divers using manual techniques, 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.

Figure 6.6. Juvenile green turtle recovered during the Morris J. Berman *barge spill in the waters off Culebra, Puerto Rico. The turtle exhibited signs of eye irritation. It was cleaned by the Puerto Rico Department of Natural Resources and released off the island of Vieques. Photo courtesy of Bradford Benggio, NOAA.*

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 (Petrae 1995). At least three additional sea turtles (one green and two hawksbills), affected by oil that was not attributed to the *Berman* spill, were also collected. In addition to turtles, thousands of live and dead oiled organisms washed ashore (Mignucci-Giannoni, 1999), including birds, invertebrates, and fish (Petrae 1995, Mignucci-Giannoni 1999).

2000 Fort Lauderdale, Florida, Mystery Spill

On 8 August 2000, a spill of unknown origin began washing up along Florida's east coast from North Miami to Pompano. Tarballs from 16 mm to pancake and mat size impacted several beaches, sometimes mixed with wrack. The oil was heavy and highly weathered. 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 continuous, 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, an estimated 530 sea turtle nests were on beaches in the area. In John U. Lloyd State Park, 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 release in 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.

NRDA -
Natural Resource Damage Assessment.

More than 137,000 loggerhead, green, and leatherback hatchlings (hatched within the previous 30 days) were estimated to be in the area and potentially exposed to oil. Natural Resource Damage Assessment (NRDA) modeling 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 model also indicated that some sea turtles were likely killed by the oil, even though no oiled turtles were recovered. The model estimate for hatchling mortality was 7,800. Loggerheads, which are most abundant in the area, were presumed most seriously impacted; green and leatherback turtles were presumed affected to a much lesser extent.

2001 Auxiliary Oiler USS *Mississinewa*

In November 1944, the U.S. Navy auxiliary oiler USS *Mississinewa* was sunk by a Japanese manned suicide torpedo in Ulithi Lagoon, Yap Island, Federated States of Micronesia. The vessel was reportedly loaded with 440,000 gal of aviation gasoline and a full load of fuel oil. The *Mississinewa* rested on the bottom for decades, but in July 2001 a tropical storm disturbed the wreck site and oil leaked to the surface.

The island group comprising Ulithi Atoll is quite large and is one of the most important green and hawksbill aggregating and nesting areas in the western Pacific Ocean. Although comprehensive population surveys had not been conducted, several hundred green turtles were counted and tagged during a census undertaken shortly before the spill (S. Kolinski 2001[4]); about 1,000 migratory (nonresident) green turtles were estimated to use the atoll each year. The timing of the oil release (reported to U.S. authorities in August 2001) was of particular concern: it was about the expected peak during hatching.

No impacts to turtles were reported during the shoreline surveys or salvage operations that followed. Turtles are an important aspect of Ulithi native society, providing food and representing a central focus for mythology and a cultural governance system extant for hundreds of years:" … myth-makers have served to endow the senti-

ment toward sea turtles with an aura of antiquity and sacredness . . ." (Lessa 1984). To the extent that strict cultural traditions strongly influence turtle harvests in the islands, they represent a de facto conservation ethic. A catastrophic incident affecting the continued viability of sea turtles in the region would have far-reaching effects, to the turtles and to the social fabric of the human inhabitants. The deterioration of that social fabric would further weaken traditional controls on harvest, accelerating the demise of the region's turtles.

Impacts of Tarballs

Impacts on sea turtles of tarballs not associated with a particular oil spill have been documented frequently (Carr 1987). Witham (1983) reported several instances of small sea turtles impacted by oil or tar along the Florida coast. In many cases, tar sealed the mouths and nostrils of the small turtles, and several turtles had ingested tarballs.

Witherington (1994) found that over 34 percent of post-hatchling sea turtles captured and examined in the Atlantic Ocean off Florida in 1993 contained tar in their stomachs and esophagi, and over half of the turtles had tar caked in their jaws. A subsequent survey of 66 neonate loggerhead turtles captured in downwelling lines near the Gulf Stream front off Florida (Witherington 2002) documented ingested tar in 20 percent of them. Chemical analysis of the tar samples indicated multiple sources and degrees of weathering.

Neonate - post-hatchling.

Van Vleet and Pauly (1987) chemically analyzed tar found in or on several stranded sea turtles collected along the Florida coast and throughout the Gulf of Mexico; they concluded the tar had originated from crude oil tanker discharges. They also reported that analysis of internal organs and feces from dead and live sea turtles indicated that turtles actively ingest floating oil and that oil residues may remain in the turtles' digestive tracts for several days. The researchers suggested that crude oil tanker discharges are having a significant impact on marine turtle populations in the eastern Gulf of Mexico.

Oil-Related Strandings

It has been estimated that approximately 1 percent of annual sea turtle strandings are associated with oil.[5] Higher percentages are attributed to oil in South Florida (3 percent) and Texas (3 to 6 percent) (Lutcavage et al. 1997), while much lower percentages characterize strandings in Hawaii (one individual in 18 years) (G. Balazs 2002[21]). Specific counties in Florida and Texas reported high rates for particular years (over 37 percent, for example, in Dade County, Florida). Work by Vargo et al. (1986) indicated that juveniles are more affected than adults and that certain species, such as green turtles, are more affected than others, perhaps due to habitat preference and location of nesting beaches.

Among the impacted sea turtles, tar is often found in the mouth, esophagus, or stomach, particularly in hatchlings and young turtles. Small sea turtles have been found completely mired in oil. Oil removed from stranded sea turtles in Florida and Texas has been identified primarily as tanker discharges.

Bugoni et al. (2001) recovered and examined dead, stranded sea turtles on the coast of Brazil and found that oil was a relatively minor occurrence in the green turtles examined between 1997 and 1998. Of 38 individuals examined, only one contained oil. By far, plastic debris (bags and ropes) was the most common anthropogenic material found (in 16 and 15 individuals, respectively).

The Future

While we cannot predict the future, trends over the past 20 to 30 years provide clues to what could happen in the coming decade. The typical tropical spill that NOAA responded to during the past decade involved a vessel grounded nearshore and spilling about 4000 gal of diesel or No. 2 fuel oil. The typical vessel was a freighter, bulk carrier, or fishing vessel. This would suggest that, in the United States, to protect sea turtles and their habitats response planners should anticipate small- and medium-sized nearshore fuel oil spills. However, this will not be the case for other parts of the world's oceans, where the prevalent oil types and transportation modes differ.

Concerns

Review of the case history files permits us to define some areas of concern or 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. During 1992 to 2001, sea turtles or turtle habitat were a concern in only about half the actual or potential spills within their nominal range. 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 turtle territory. This suggests that the incidents were either not considered a real risk despite the potential or (less likely) the threat was simply overlooked.

The body of case histories does not reflect a pattern of significant impact of oil spills on sea turtles. Thus, it is possible that sea turtles have not been seriously affected by spills. It is also possible that impacts on turtles were not reported because impacted individuals were not observed or were only discovered after response actions were terminated. If that is the case, more work is needed to connect damage assessment and restoration information to response information.

While the public and media tend to view crude oil spills from large tankers as threats to wildlife, most incidents were from vessels other than tankers and from station-

ary sources such as pipelines and dock facilities. This distribution among spill sources is consistent with other larger assessments, such as that done by the National Research Council (2002). Most knowledge about the effects of oil on sea turtles—scant as it is—is based on exposures to crude oil, but we now realize that information is also needed about effects of fuel oils and dispersed oil, and effectiveness of shoreline and nest site protection strategies. While it seems unlikely that intentional oil exposure experiments with live sea turtles will be permitted or accepted anytime in the near future, other biochemical or molecular assays that could be performed *ex situ* may be one way to obtain toxicological information without harming or stressing threatened turtles.

For Further Reading

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Chapter Notes

[1] By comparison, the *Exxon Valdez* spill in Prince William Sound, Alaska, was 10.9 million gal.

[2] This listing is not comprehensive.

[3] A. Meylan, Florida Fish and Wildlife Conservation Commission, Florida Marine Research Institute, 100 Eighth Avenue SE, St. Petersburg, FL 33701-5095, personal communication, 2002.

[4] S. Kolinski, Department of Zoology, University of Hawaii at Manoa, 2538 McCarthy Mall, Honolulu, HI 96822, personal communication, 2001

[5] As identified by the U.S. Sea Turtle Stranding and Salvage Network.

[6] G. Balazs, Marine Turtle Research Program, NOAA/NMFS Southwest Fisheries Science Center, 2570 Dole Street, Honolulu, HI 96822-2396, personal communication, 2002.

Conclusions

We have presented a large amount of material for your consideration in this document. Our intent was to consolidate a body of disparate information on sea turtles into a single place, and interpret it within the framework of oil effects and spill response activities. Our conclusions include the following:

- Six species of sea turtles are found in the United States or in U.S.-territorial waters: leatherback, green, Kemp's ridley, hawksbill, loggerhead, and olive ridley.
- All six turtle species are listed under the Endangered Species Act, thus are subject to special protection.
- Sea turtles worldwide are threatened by a variety of natural and anthropogenic influences. Among those of human origin, incidental catch and death in fisheries for other species is the most prevalent.
- Aspects of the life histories of sea turtles place them at heightened risk due to the intersection and overlap with areas where oil collects.
- Even though direct exposure studies are quite limited, there is strong, if dated, information that indicates oil is harmful to turtles. Dermal tissues and membranes appear to be particularly sensitive to exposure.
- Fresh oil harms sea turtle eggs; weathering reduces the toxic effect.
- Spills in which turtle injury has been documented are relatively rare.
- The threat from oil spills was demonstrated by Ixtoc I, in which the only known nesting site for a highly endangered turtle species was narrowly missed, and by the growing transport of petroleum products across waters representing important turtle habitat.
- In the U.S. waters where sea turtles are found, historical records suggest that the most prevalent spills have involved refined fuel oils from barges or freighters and have occurred as a result of vessel grounding.
- Response activities have the potential to adversely affect sea turtles, both on the water and on the beach. Probably the greatest potential for impact exists in beach-

related oiling and cleanup, which could disturb nesting females, nests, and hatching turtles, due to the large numbers of animals that could be affected in a relatively small area.

Our goal in structuring a response to an oil spill in sea turtle habitat will be to evaluate the tradeoffs of various actions against the effects to all of the identified resources at risk. When sea turtles are judged to be a priority for protection, then we can modify the response to accommodate some of the many special aspects of sea turtle biology that have been discussed here and elsewhere. While we are not likely to completely eliminate spill-related stress to potentially affected animals, we may be successful in reducing one source of stress to these threatened populations. In doing so, we improve their chances for survival in an increasingly challenging ocean environment.

Photo courtesty of Dr. Asaf Senol, Department of Environmental Protection, Ministry of Tourism and Environment, Turkish Republic of Northern Cyprus.