NOAA Technical Memorandum NMFS-OPR-69

Northern Gulf of Mexico Sea Turtle Strandings: A Summary of Findings and Analyses from 2015–2019

NOAA - Office of Protected Resources
Lyndsey Howell
Brian Stacy
Robert Hardy
Jennifer Keene

NOAA - Southeast Fisheries Science Center
Melissa Cook
Emma Schultz

National Centers for Environmental Information / Mississippi State University
Zhankun Wang

Mississippi State University
Mark Lawrence
Debra Moore
Tim Morgan

Institute for Marine Mammal Studies
Moby Solangi

U.S. DEPARTMENT OF COMMERCE

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*These authors contributed equally to this work

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Contributors:

NOAA - Office of Protected Resources	NOAA - Southeast Fisheries Science Center	National Centers for Environmental Information / Mississippi State University	Mississippi State University	Institute for Marine Mammal Studies
Lyndsey Howell Brian Stacy Robert Hardy Jennifer Keene	Melissa Cook Emma Schultz	Zhankun Wang	Mark Lawrence Debra Moore Tim Morgan	Moby Solangi

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U.S. Secretary of Commerce
Gina M. Raimondo

Under Secretary of Commercefor
Oceans and Atmosphere

Richard W. Spinrad

Assistant Administrator for Fisheries
Janet Coit

October 2021

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List of Acronyms

Acronym

AMSEAS – American Seas Ocean Model

BPI – Beaching Probability Index

CFR – Code of Federal Regulations

COLREGS – Convention on the International Regulations for Preventing Collisions at Sea

EEZ – Exclusive Economic Zone

DWH – Deepwater Horizon

ELISA – Enzyme-linked immunosorbent assay

FWRI – Florida Wildlife Research Institute

GIS – Geographic Information System

GLM – Generalized linear model

GMT – Greenwich Mean Time

LC-MS/MS – Liquid chromatography with tandem mass spectrometry

MLLW – Mean Lower Low Water

MMPB – Total Adda microcystins and nodularins

MRM – Multiple reaction monitoring

NCOM – Navy Coastal Ocean Model

NDBC – National Data Buoy Center

NGOM – Northern Gulf of Mexico

NMFS – National Marine Fisheries Service

NOAA – National Oceanic and Atmospheric Administration

PbTx – Brevetoxins

PSP – Paralytic shellfish poisoning

SCL – Straight carapace length

STSSN – Sea Turtle Stranding and Salvage Network

SPE – Solid phase extraction

USACE – US Army Corps of Engineers

Acknowledgments

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Executive Summary

The Sea Turtle Stranding and Salvage Network (STSSN) in the northern Gulf of Mexico (NGOM) began a consistent period of operation following enhancements to the network after the 2010 *Deepwater Horizon* (DWH) oil spill. This report presents information, analyses, and conclusions related to the study of sea turtle strandings by NGOM STSSN collaborators in three states, Alabama, Mississippi, and Louisiana. We include the following elements:

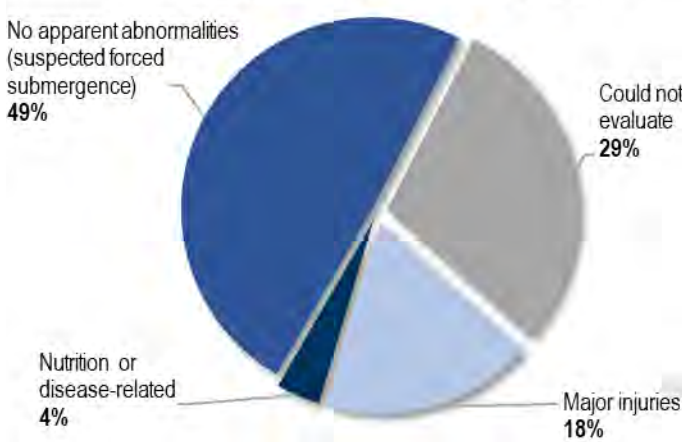
- **Stranding and postmortem information for 2015–2019 compared to previous years;**
- **Environmental analyses and modeling pertinent to stranding causes and trends;**
- **A 10-year review of sea turtle incidental capture records.**

The number of sea turtle strandings in the NGOM during 2015–2019 was 50% lower than during the previous 5 years due to a significant reduction in Kemp's ridley turtle strandings. Concurrently, there was a decrease in the frequency of incidental recreational captures of Kemp's ridleys, suggesting a change in regional sea turtle distribution or abundance. Multiple possible factors requiring additional study may have contributed to these observations and warrant the continuation of monitoring efforts.

Nearly half of all stranded sea turtles within the NGOM were nutritionally robust animals without injuries or disease. Drowning by forced submergence in fisheries is suspected based on necropsy findings and exclusion of other causes. These strandings exhibited a consistent seasonal pattern, peaking during spring and continuing through summer. Drift studies and oceanographic models show that the turtles most likely died near their stranding locations and that prevailing winds/currents and environmental conditions contribute to the seasonality of strandings. Further effort is needed to identify potential mortality sources and mitigation measures, including projects planned under DWH restoration.

Other causes of NGOM sea turtle mortality included major injuries. Vessel strikes were the most frequent injury type and were often observed near high vessel traffic areas. Turtles in poor nutritional condition or with evidence of disease accounted for the fewest strandings. As many stranded sea turtles found in the NGOM are decomposed upon discovery, nearly 30% of strandings could not be evaluated due to postmortem condition.

Predominant Findings Among Stranded Sea Turtles in the Northern Gulf of Mexico 2015-2019



1. Introduction

The Sea Turtle Stranding and Salvage Network (STSSN) is a cooperative network of federal and state agencies, authorized non-governmental organizations, local governments, academic institutions, and permitted public participants. These partners respond to and document stranded sea turtles on the Atlantic and Gulf of Mexico coasts of the U.S., Puerto Rico, and the U.S. Virgin Islands. Any sea turtle located on land or in the water that is either dead or alive but cannot undergo normal behaviors (e.g., swimming, diving, feeding) is considered "stranded" and is documented by the STSSN. The STSSN also records select types of incidental captures, including sea turtles caught by recreational anglers. All sea turtle species commonly found in U.S. waters have been reported among strandings in the Gulf of Mexico, including the Kemp's ridley turtle (*Lepidochelys kempii*), green turtle (*Chelonia mydas*), loggerhead turtle (*Caretta caretta*), hawksbill turtle (*Eretmochelys imbricata*), and leatherback turtle (*Dermochelys coriacea*). All sea turtles are listed as threatened or endangered under the U.S. Endangered Species Act of 1973, as amended (16 USC §1531 et seq.).

This report focuses on the data collected by the STSSNs from three northern Gulf of Mexico (NGOM) states, Alabama (AL), Mississippi (MS), and Louisiana (LA), which are all coordinated by NOAA Fisheries. In the 1980s, various federal, state, and non-governmental organizations in the NGOM began responding to stranded sea turtles; however, detection and documentation were not consistent across the region. As a result, historical records are not comprehensive for most areas. On April 20, 2010, the *Deepwater Horizon* (DWH) mobile drilling unit exploded and resulted in a massive release of 3.19 million barrels of oil and other substances into the NGOM over nearly three months. The NGOM STSSN was enhanced during and following the oil spill. The STSSN has expanded and improved stranding response and mortality investigation in subsequent years. Sea turtle strandings are monitored for changes in causes of mortality or illness, new or previously unrecognized threats, and identifying changes or trends relevant to population recovery or wildlife health.

Within this report, we present findings from sea turtle stranding and mortality investigation efforts from 2010–2019, including collection and review of stranding information and photographs, postmortem examinations (necropsy), biotoxin analyses, analysis of relevant weather and oceanographic data, and drift analysis for a selected subset of stranded turtles. We also update NGOM stranding data provided in previous summaries for 2010–2014 (Stacy, 2012; 2015) based on additional records and other information for this period collected subsequent to these earlier reports, and review reports of incidental captures resulting from various activities, including recreational fishing, for the entire 10-year period. These elements collectively represent a decade of sea turtle stranding and incidental capture observations and studies following the implementation of consistent STSSN operations in the NGOM. Comprehensive information related to oiled sea turtles documented throughout the DWH spill response is available through other reports (Stacy, 2012; Stacy et al., 2017a; Stacy et al., 2017b). All information is presented by region and state for ease of reference and to facilitate use by resource agencies and stakeholder groups.

Sea turtles of the northern Gulf of Mexico

Five species of sea turtle are found within the Gulf of Mexico. Kemp's ridley turtles are the most common species found stranded in the northern Gulf of Mexico, followed by loggerhead and green turtles. Leatherback and hawksbill turtles rarely strand in this region. For more information about each species, please visit: https://www.fisheries.noaa.gov/species-directory.

2. Methods

2.1 Stranding documentation

Stranded sea turtles are documented through public reports and discovery during dedicated beach surveys (e.g., sea turtle nesting and stranding surveys, bird surveys, and other coastal monitoring efforts). Each stranded sea turtle is documented by a trained and authorized STSSN participant. Stranding reports include photographs of the turtle and a complete reporting form (Appendix A) based on their observations or information provided by the reporting party if the stranding responder does not directly observe the turtle (e.g., from reports or photographs submitted by the public). The reporting form includes the date and location of discovery (latitude and longitude), circumstances of stranding, species, condition (i.e., alive or degree of decomposition), measurements, tag information, and notation of external abnormalities (e.g., injuries, disease, abnormal accumulations of epibiota, and anthropogenic materials). The stranding location includes state, county, waterbody designation (inshore or offshore), and NMFS statistical zone. The straight carapace length (SCL) measured from the nuchal notch to the caudal tip of the carapace was used for size comparisons in this report. If the responder only collected curved measurements, the straight measurement was derived using regression equations provided in Teas (1993).

2.2 Necropsy and diagnostic analyses

Postmortem examinations

Turtle necropsies followed routine methods (Stacy et al., 2017a), including examining all organ systems to the degree afforded by the postmortem condition. A standardized necropsy reporting form (Appendix A) was used to record all gross findings. When possible, pericoelomic fat (representing nutritional condition) and all significant abnormalities were photographed. Tissues were sampled from recently deceased or minimally decomposed turtles for histopathology. These tissues were preserved in 10% neutral phosphate-buffered formalin, processed into paraffin blocks, and 5µm sections were mounted on glass slides and stained with hematoxylin and eosin. In addition, decomposed turtles with gross abnormalities were selectively sampled for histopathology.

Nutritional condition. The nutritional condition of a sea turtle can be evaluated by comparing body mass to length, visually assessing external features, or evaluating muscle mass and body fat during necropsy. Since decomposition and scavenging interfere with accurate measurement of body mass in stranded turtles, we characterized the nutritional condition of stranded Kemp's ridleys, loggerheads, and green turtles based on the appearance of their fat. Fat is metabolized before muscle and exhibits consistent color change with atrophy. Therefore, we felt that the fat condition was a reliable measure of nutritional condition for this study. Photographs of pericoelomic fat taken during necropsy were reviewed by a single observer and categorized as 1) no atrophy (robust), 2) mild atrophy, 3) moderate atrophy, or 4) severe atrophy (depleted) based on color (Figure 2-1). The fat condition was compared by year of stranding, among states, and SCL depending on the available sample size. We also considered evaluating muscle mass as a measure of body condition. However, we ultimately decided that these assessments were too subjective due to a combination of decomposition-related changes, differences in dissection technique (i.e., inconsistent removal of muscle with the plastron), and factors among individual sea turtles that affect the appearance of muscle in photographs.

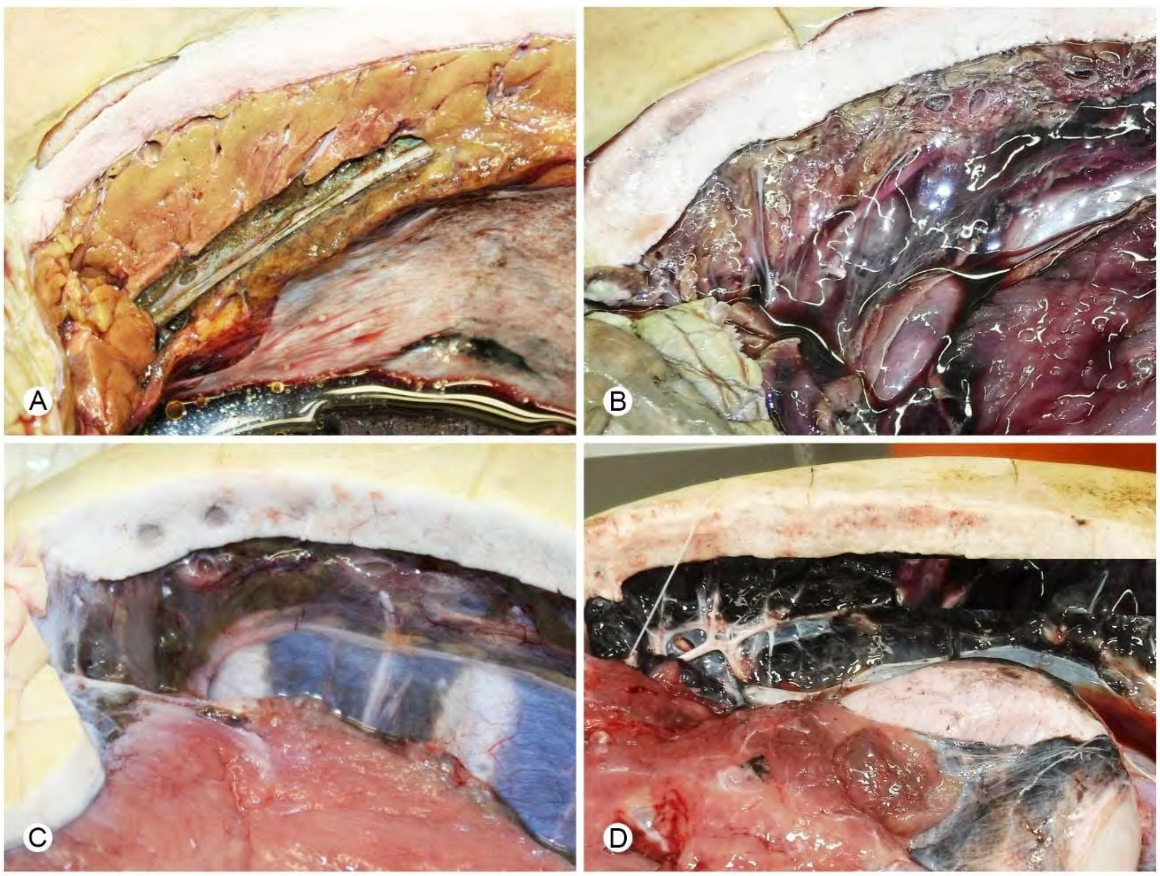


Figure 2-1. Examples of fat condition used to evaluate the nutritional condition of stranded sea turtles (current FWCC permit MTP21-08). A) Robust, non-atrophied fat. B) Mildly atrophied fat. C) Moderately atrophied fat. D) Severely atrophied fat. Sea turtle fat becomes progressively darker green with atrophy and is black when completely depleted. The dark coloration is due to pigment cells within the fat tissue.

Diet. Contents of the gastrointestinal (GI) tract were examined and explicitly characterized by type and location within the GI tract. The anatomic locations (e.g., mouth, esophagus, and stomach), and the type of food items found, were considered indicators of active or recent feeding near the time of death. Percent occurrence of finfish and penaeid shrimp within the GI tract was evaluated for each species of turtle. We focused on fish and shrimp because these organisms are not considered natural sea turtle prey items and are associated with anthropogenic food sources, such as discarded bycatch from fishing.

Biotoxin analysis. Tissues were collected from a subset of stranded turtles for biotoxin analysis. Approximately 100 g of liver and kidney and 100 ml of stomach contents and feces were stored in individual plastic bags and frozen at -20˚C until analyzed. Samples were analyzed at three different laboratories, depending on the biotoxin of interest (based on bloom type) and laboratory availability. Most analyses for brevetoxins (PbTx) were performed by Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute (FWRI). Toxins were extracted using organic solvents (80% aqueous methanol). Extracts were screened for the presence of brevetoxins and brevetoxin metabolites using a competitive enzyme-linked immunosorbent assay (ELISA) performed according to Naar et al. (2002) with modifications as described by Flewelling (2008). Toxin concentrations were calculated using a PbTx-3 standard curve, and results are reported in ng PbTx-3 eq/g.

Thirteen sea turtles that stranded in 2016 were analyzed for brevetoxins by the Marine Biotoxins Program, National Centers for Coastal Ocean Science. Samples (~ 2 g) were homogenized and extracted three times in 3 volumes of acetone, filtered (0.45 µm, Pall Acrodisc GxF/GHP syringe filter), evaporated, resuspended in 80% aqueous methanol (6 mL), twice solvent partitioned with hexane (3 mL), and the methanolic fraction collected, evaporated and resuspended in 100% methanol (1-2 mL, 1:1 sample:solvent). Extracts were stored at -20°C until analysis. Extracted samples were diluted (1:20) and analyzed using a direct competitive ELISA for brevetoxins, following methods outlined by Maucher et al. (2007). ELISA-positive samples were cleaned on C18 solid phase extraction (SPE) cartridges (Bond Elut 500 mg, Agilent) and analyzed by liquid chromatography/mass spectrometry (LC-MS/MS) for parent brevetoxins and metabolites. Sample extracts with each equivalent to 0.5 g of tissues were loaded on the conditioned SPE cartridges (using methanol then water) in 25% methanol, sample tubes were then washed with 6 ml 25% methanol and the wash solution of each sample was transferred to the SPE cartridge, brevetoxins were eluted with 8 ml methanol. The SPE eluates were dried with a turboevaporator at 40°C, and the dried residue in each tube was dissolved in 0.5 ml methanol for analysis. Liquid chromatographic separations were performed on a Luna C8 (2) column (150 × 2 mm, 5µm; Phenomenex, Torrance, CA) using an Agilent Technologies Model 1100 LC system. Mobile phase consisted of water and acetonitrile with 0.1% formic acid additive with gradient elution. The mobile phase flow rate was 0.2 mL/min. The LC eluent was analyzed by an AB Sciex 4000 QTRAP hybrid triple quadrupole/linear ion trap mass spectrometer equipped with a TurboVTM electrospray interface. The analysis of brevetoxin congeners and metabolites by mass spectrometry was achieved by multiple reaction monitoring (MRM). Brevetoxin congeners monitored included: brevetoxin-B(A) using MRM transitions of m/z 895.5 → 877.5 and m/z 867.5 → 849.5, dihydrobrevetoxin-B(A) using MRM transitions of m/z 897.5 → 725.5 and m/z 869.5 →779.5, tetrahydrobrevetoxin-B using MRM transition m/z 899.5 → 863.5, hydrolysis products of brevetoxin-B(A) and dihydrobrevetoxin-B(A) using MRM transitions of m/z 913.5 → 877.5, m/z 885.5 → 867.5, m/z 915.5 → 743.5, m/z 887.5 → 869.5, hydrolysis product of oxidized brevetoxin-B using MRM transitions of 929.5 → 893.5, brevetoxin-B2 using MRM transition of m/z 1034.5 → 929.5, S-desoxybrevetoxin-B2 using MRM transitions of m/z 1018.5 → 204.2 and 929.5, and cysteine conjugates of brevetoxin-A using MRM transitions of m/z 990.5 → 901.5 and m/z 1006.5 → 901.5. Detection limits were 0.3, 1.7, and 1.2 ng/ml for dihydrobrevetoxin-B, S-desoxybrevetoxin-B2, and brevetoxin-B2, respectively, for toxin standards in methanol, with a signal-to-noise ratio slightly above 3. Retention times of other algal toxin congeners were determined by injecting an algal extract containing known toxin congeners. Retention times of cysteine conjugates of brevetoxin-A were determined by injecting a sample extract containing the metabolites as confirmed previously by enhanced product ion spectra. Results were reported as "positive," indicating confirmation of PbTx or not detected, indicating presence could not be verified by LCMS.

Five stranded Kemp's ridleys found in Mississippi during June and July 2019 were analyzed for exposure to microcystins and nodularins produced by cyanobacteria. Samples were first screened by FWRI using a validated ELISA. All positive results were subsequently analyzed for total Adda microcystins and nodularins (MMPB) by liquid chromatography and tandem mass spectrometry (LC-MS/MS) performed by GreenWater Laboratories (Foss et. al, 2020). Samples were cut (≤ 1 mm^3) and subsampled (ca 2-3 grams wet weight). Subsamples were transferred to homogenization vials with 10 mM phosphate buffer (pH=7) to achieve sample concentrations of 100 mg/mL. An Omni Bead Ruptor was used to homogenize the samples (6.3 m/s for 30s). Aliquots were dispensed into glass vials for extractions. Material was oxidized as 50 mg (w.w.) or 300-500 μL (extracts in duplicate) aliquots with peroxidation LFSMs. Subsets were oxidized with the addition of 2.5 mL of oxidant composed of 0.2 M K2CO3, 0.1 M KMnO4 and 0.1 M NaIO4. Oxidation was stopped by the addition of sodium bisulfite (40%). The oxidized aliquots were centrifuged and the pellets were rinsed with 1 mL of deionized water. The pooled supernatants were cleaned using Strata X solid phase extraction (SPE) followed with Simplified Liquid Extraction (SLE). The ethyl acetate elutions from SLE were blown to dryness and reconstituted in water at a final concentration of 100 mg/mL for wet weight samples and at 1x (125 mg/mL; based on notation on vial stating 0.25 grams material per 2 mL extract) for extracts 7, 8, and 9. The extracts were filtered through 0.2 μm PVDF and analyzed for MMPB. For LC-MS/MS, the [M-H] - ion of MMPB (m/z 207) was fragmented and the product ion m/z 131 was monitored. A standard curve (0.25, 0.5, 1, 2, 5, 10, 50, 100 ng/mL of oxidized MC-LR) was used to calculate MC-LR spike returns. Pre-oxidation LFSMs were used in quantitation. The MDL was estimated using an S: N level of 3.

In addition, we reviewed the FWRI Red Tide Current Status website[1], the National Oceanic and Atmospheric Administration's (NOAA) Gulf of Mexico Harmful Algal Bloom Bulletins[2], and Mississippi Department of Environmental Quality Beach Monitoring Program website[3] for field reports of blooms, advisories, fish kills, and human respiratory irritation.

2.3 Stranding characterization

Circumstance of stranding, categories, photograph review

Stranding records from each state were cross-referenced with the STSSN database maintained by NOAA Fisheries. Stranding reports were reviewed for information relevant to the circumstances of stranding. Our analysis focused on "traditional strandings," which is implied in the use of "stranding" or "stranded sea turtle" throughout this report unless otherwise noted.

The following circumstances of stranding are not considered traditional strandings and were excluded from our analyses:

- cold-stunned sea turtles (n = 9)
- hatchlings (recently emerged or released) or posthatchlings (under 10 cm SCL; n = 13)
- disoriented nesting females (n = 9)

Traditional strandings were binned by five years (2010–2014 and 2015–2019) for each NGOM state. Stranding reports and photographs were reviewed for abnormalities or other factors contributing to the cause of stranding. Stranded sea turtles were categorized based on predominant findings observed at the time of stranding or postmortem findings (if necropsied) using the criteria in Table 2-1. We created these categories to group strandings by the identified or likely stranding cause (e.g., trauma, disease-related) or to capture specific characteristics that could be used to identify possible causes for further investigation (i.e., those without major abnormalities). Briefly, turtles without anomalies did not have an apparent cause of stranding or signs of poor health based on gross examination, and nutritional condition was determined to be within normal limits for the species. For purposes of this report, turtles within this category are referred to as having "no anomalies"; however, as subsequently presented, many had observations that were potentially

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1 https://myfwc.com/research/redtide/statewide/

2 https://tidesandcurrents.noaa.gov/hab/gomx.html

3 https://opcgis.deq.state.ms.us/beaches/

relevant to the immediate cause or circumstances of death, such as sediment within the respiratory tract or prior feeding on finfish.

Sea turtles with significant injuries had a wound(s) confirmed to have resulted in stranding, or that was severe enough to have caused stranding if causation (e.g., wound vitality) could not be confidently established (e.g., due to decomposition). We did not include healing wounds (or healed)

Table 2-1. Stranding categories and criteria applied to sea turtle strandings in Alabama, Mississippi, and Louisiana 2010–2019. Criteria were applied to both stranding findings and necropsy observations if postmortem examination was conducted.

Observation	Criteria
Stranding	No visible abnormalities (e.g., injuries, abnormal epibiota, emaciation)
Necropsy	Fair or good nutritional condition based on the condition of muscle and fat AND no evidence of any significant disease process (including accumulated epibiota) AND no major injuries
Stranding	Major injury present (does not include disarticulation or other changes attributable to decomposition or obvious scavenging). All injuries are subcategorized as: • Vessel strike (parallel wounds or major blunt force injuries) • Fishing gear related (fishing line, tackle, netting) • Non-fisheries entrapment/entanglement • Shark bites • Other types of injuries
Necropsy	Major injury identified that might have caused or contributed to stranding
Stranding	Emaciation, anomalous epibiota, or other major non-injury abnormality
Necropsy	Nutritional condition is diminished (severe atrophy of muscle/fat) OR significant pathological lesions indicating disease state
	Decomposition, scavenging, or inadequate documentation prevented categorization

without apparent complications or those caused by scavengers based on necropsy or field information. The type of injury was identified, such as wounds attributable to vessel strikes, entangling material or ligature wounds, and shark bites. Underweight or emaciated turtles, those with anomalous epibiota accumulation, or those with evidence of a significant disease process, were placed into the disease-related category. Turtles without photos, inadequate documentation, advanced decomposition (e.g., dried or skeletal remains only), or heavily scavenged were grouped into the insufficient data category as "unclassified."

Spatial information associated with stranding records

The following spatial information associated with stranding records was verified: county, statistical zone, and water body classification.

The county where strandings were documented was confirmed by intersecting stranding location with a modified version of the shapefile: Coastal Zone Management Program counties of the United States and its territories (Hartwell et al., 2013). This dataset was revised to extend state waters to nine miles and correct boundary digitization errors. The data source for the state waters boundary used in this revision was the Federal and State Waters dataset provided by the NOAA Office for Coastal Management (2020).

The STSSN classifies strandings as occurring within either inshore or offshore waters. Inshore strandings were found within or along the shores of bays, lagoons, sounds, and passes. Offshore strandings were documented within Gulf of Mexico waters or along Gulf-facing beaches. The boundary between inshore and offshore waters was based on the demarcation lines specified by the Convention on the International Regulations for Preventing Collisions at Sea, 1972 (commonly referred to as COLREGS, 30 Code of Federal Regulations (CFR) § 80). We developed a spatial polygon dataset describing the inshore and offshore portions of all Gulf of Mexico and Atlantic Ocean waters within the U.S. Exclusive Economic Zone (EEZ). This boundary was based on the COLREGS lines where they were available (e.g., near inlets). The terrestrial boundary between the inshore and offshore zones was formed by digitizing a line along the shoreline, inshore of the areas influenced by waves or high tides (e.g., beaches). This delineation was based on recent aerial or satellite imagery and followed portions of the shoreline that appeared least susceptible to inundation (e.g., lines of permanent vegetation, roads). We used existing stranding records and sea turtle distribution knowledge to determine the landward boundary of inshore waters.

Additional data related to surveys for stranded sea turtles and changes in effort over time were available for Mississippi; therefore, stranding locations were classified into three location categories (mainland, barrier island, and marsh/sound) for this state. These designations were determined by the location description documented for each stranding record. Location categories were compared between each five-year period (2010–2014 and 2015–2019) for each species to explore any changes in location reporting from recent dedicated monitoring surveys on the barrier islands and expansion of the Mississippi STSSN.

Backtracking analysis

We estimated the location where debilitation or mortality likely occurred using carcass backtracking methods outlined by Nero et al. (2013) and Nero et al. (in review) for a subset of strandings. Stranded sea turtles without apparent anomalies were the focus of these analyses due to questions related to their locations of origin and circumstances of death. The analysis involved backtracking the carcasses' likely drift from where they were discovered on the shore. Turtle carcasses were backtracked as Lagrangian surface particles forced by water currents and winds at 15-minute time steps. The model was developed for moderately or severely decomposed turtles based on assumptions of decomposition rates, buoyancy, and persistence in the environment; therefore, only strandings in these conditions were included in backtracking analyses. We created summary heat maps from selected backtracking results of carcasses with no anomalies to show the probability density of where stranded sea turtles may have originated (i.e., where mortality may have occurred) based on algorithms that use carcass condition, sea temperature, and water depth. Backtrack analyses were grouped by season using Alabama and Mississippi stranding data from 2017 to 2019. Seasonal groupings were Dec–Feb (winter), Mar–May (spring), Jun–Aug (summer), and Sept–Nov (fall). Louisiana data were not included in this analysis due to frequent delays between initial reporting of strandings and the subsequent documentation, which introduces errors into backcasting results.

2.4 Environmental analysis and modeling

Beaching Probability Index

The Beaching Probability Index (BPI) describes the likelihood that dead or debilitated sea turtles floating at the sea surface will be deposited on shore-based on prevailing wind and currents. BPI is an indicator of favorable beaching conditions, i.e., drifting carcasses will be more likely to beach if BPI is high and less likely to come ashore if BPI is low. This relationship between strandings and environmental conditions is relevant to our understanding of potential causes of stranding and the degree to which at-sea mortality may be represented by turtles found stranded.

The BPI applied velocity and direction of surface currents and wind from the American Seas Ocean Model (AMSEAS) of the Regional Navy Coastal Ocean Model (NCOM) to predict and describe the probability of floating turtles washing ashore. AMSEAS gives a 3 hr, ~2.8 km resolution, 1000 × 1510 grid domain of the Gulf of Mexico and the Caribbean Sea, and includes tidal, geostrophic, and atmospheric-driven water motion. Within the BPI simulation, surface currents and winds from AMSEAS were used to push particles for 8 days based on lab and field studies of decomposition and persistence of sea turtle carcasses in the environment (Nero et al., in review). Each day, at 0 h Greenwich Mean Time (GMT), new particles were seeded onto a starting grid of 84,044 points spaced 1 NM apart. This uniform grid extended from the coast to 60 NM offshore (Figure 2-2), which is the furthest distance sea turtle carcasses were likely to drift based on our observations. The system maintained a running tally such that on any given day, all objects that are still in motion and less than 8 days old were pushed forward. Particles that encountered shallow water (< 25 cm depth) stopped moving and were counted as "beached." The leeway value, the amount of "push" the wind gives a floating object, was set to 3.5%, a value applicable to sea turtles or any other floating object with about 50% of its area exposed above the sea surface (Nero et al., 2013). We compared BPI to stranding records from 2017 to 2019 when BPI data were available.

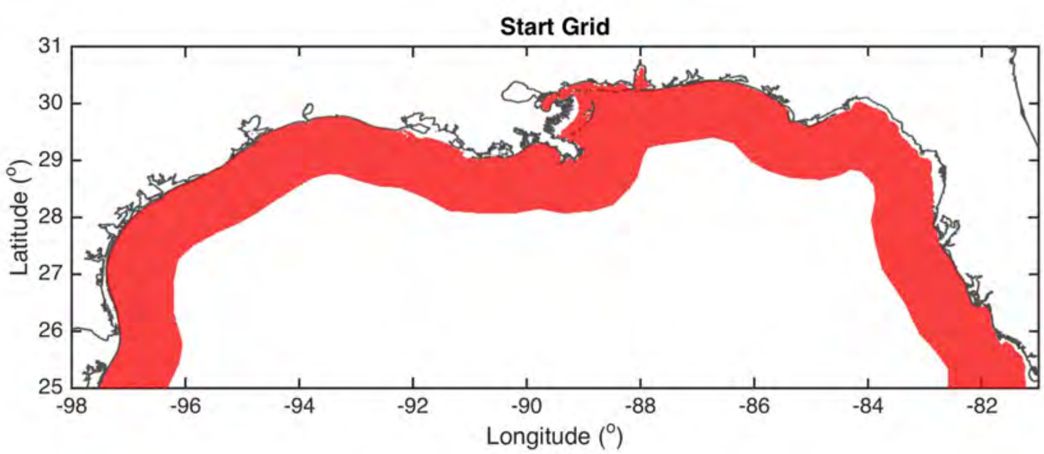


Figure 2-2. Beaching Probability Index (BPI) Start Grid for the northern Gulf of Mexico. The Start Grid is predefined as approximately 84,044 x, y starting locations spaced 1 NM apart to seed the BPI simulation.

Environmental data analysis

We reviewed environmental parameters throughout the reporting period to identify areas or periods in which environmental conditions may have led to increased sea turtle strandings. Water temperatures were examined to identify periods when temperatures were below 10°C, the threshold below which sea turtle cold-stunning may occur. We reviewed wind speed, direction, and tidal height data as periods of strong, shoreward winds or high tides may increase the likelihood of stranding of dead or debilitated sea turtles. Water temperature, wind speed, and wind direction data were obtained from the NOAA National Data Buoy Center[4] (NDBC). Data were acquired from

[4] https://www.ndbc.noaa.gov/

NDBC stations situated in three areas representative of NGOM strandings: Calcasieu Pass, LA, Grand Isle, LA, and Dauphin Island, AL (Fig. 2-3). The stations selected provide both meteorological conditions and ocean temperatures representative of the three regions' nearshore conditions.

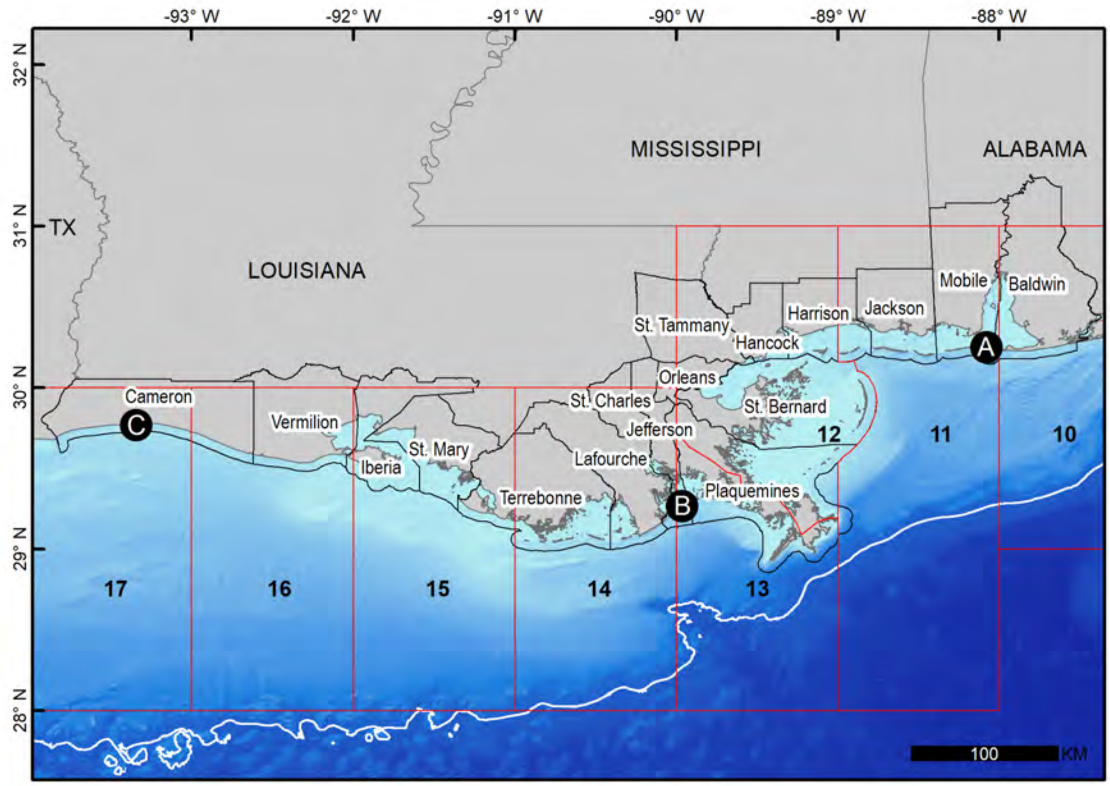


Figure 2-3. The northern Gulf of Mexico coastal counties and state waters (grey lines) where sea turtle strandings were documented within and along the shorelines of bays, lagoons, sounds, and Gulf of Mexico waters. National Marine Fisheries Service statistical zones (red lines) were used to group data into similar-sized regions. Labeled circles indicate the locations of NOAA National Data Buoy Center stations from which environmental data were obtained: Dauphin Island, AL (A), Grand Isle, LA (B), and Calcasieu Pass, LA (C). Bathymetry data were obtained from the U.S. Coastal Relief Model (NOAA National Geophysical Data Center, 2001). White line represents the 200 m bathymetric contour.

Freshwater diversion - Bonnet Carré Spillway

The U.S. Army Corps of Engineers (USACE) developed and implements the Mississippi River flood control plan. The plan consists of levees, floodways, channel stabilization, and tributary basin improvements designed to protect communities along the Mississippi and Ohio rivers and reduce the flood heights on the levees on the Missouri side. The Bonnet Carré Spillway (BCS), or Bonnet Carré Floodway, is located about 50 km upstream from New Orleans and was constructed in 1931 as part of an integrated flood-control structure for the lower Mississippi River Plain. The spillway is operated only at extremely high river stages and is designed to divert water from the Mississippi River into Lake Pontchartrain and eventually into the western Mississippi Sound. When fully opened, the spillway can divert approximately 7,100 cubic meters of water per second and relieve pressure on levees downstream.

Yearly data on the BCS operation, including the opening dates, number of days opened, number of bays opened, and total discharge were obtained from the USACE - New Orleans District website (USACE 2021). Mississippi stranding data were analyzed monthly to compare the total stranding numbers preceding, throughout, and following the openings and years without openings. Sea turtle strandings are rarely reported in adjacent areas of Louisiana due to the remoteness of these marshlands and barrier islands; therefore, analyses were only conducted using Mississippi stranding data.

2.5 Statistical analyses

Parametric or non-parametric statistical analyses of parameters relevant to the characterization of strandings and/or identification of possible causes were used appropriately based on data characteristics. *P*-values less than .05 were considered significant. Proportions are only provided for sample sizes greater than ten; actual numbers are given whenever the frequency of occurrence is stated for an observation.

Correlations between weekly mean BPI values and strandings during 2017 to 2019 (years with available model data) were examined separately for each state and region of interest (Mississippi – Alabama, Central Louisiana, and West Louisiana) in two ways. First, we evaluated the overall correlation between the two variables using Kendall's rank correlation implemented in R (R Development Core Team 2019). Next, we modeled the effect of weekly mean BPI values on stranding counts using a log-linked quasi-Poisson generalized linear model (GLM) in R.

2.6 Incidental captures

Sea turtles captured directly incidental to an activity such as fishing (recreational or commercial), dredging, research activities, or power plant operations are classified as incidental captures by the STSSN and are not considered traditional strandings. Depending on the activity, the interaction may result in injury or death to the animal. Records from each state were collected by NOAA and cross-referenced with the STSSN database. STSSN reports were reviewed for information relevant to the circumstances of the incidental capture and summarized by state, species, SCL, date, and type of activity.

3. Results

3.1 Regional strandings

During 2015–2019, 1,210 stranded sea turtles were documented in Alabama, Mississippi, and Louisiana (Table 3-1). Stranding data are presented by species and condition in Table 3-2. More Kemp's ridleys stranded (n=870) than all other species combined (n = 340; 172 loggerheads, 100 green turtles, 3 leatherbacks, and 65 sea turtles that could not be identified to species). Total region-wide strandings (n = 1,210) decreased by 49.8% from the previous 5 years (n = 2,408). This reduction was due to fewer Kemp's ridley strandings, which decreased by 58.0% (2,073 to 870). In contrast, loggerhead strandings increased by 23.7% (139 to 172) in the most recent 5-year period, and the numbers of green turtle strandings were similar between the periods. No hawksbills were documented as traditional strandings from 2015 to 2019. Additional information related to photo documentation and necropsy of stranded sea turtles is provided in Suppl. Table B-1

The average weekly stranding numbers for the 5-year and 10-year averages exhibited a seasonal pattern with strandings increasing in the early spring, peaking in April, declining in May, and having a second, smaller peak in June (Fig. 3-1). Strandings were clustered within three general areas: Mississippi–Alabama, central Louisiana, and western Louisiana (Fig. 3-2), which is attributable to shoreline geomorphology and accessibility (to the public or stranding responders) and does not necessarily represent the distribution of sea turtles or threats within the region.

Most Kemp's ridleys were moderately (37.9%, 330/870) or severely decomposed (48.4%, 421/870) (Table 3-2). Loggerheads were most frequently severely decomposed (50.0%, 86/172) and most of the green turtles were moderately decomposed (42.0%, 42/100). Histograms of the SCL of stranded turtles are shown by species in Figure 3-3. Mean SCL was 41.1 ± 13.2 cm (mean ± one standard deviation [SD], range: 18.0–67.9 cm, n = 608) for Kemp's ridley turtles, 73.4 ± 14.2 cm (range: 11.8–100.5 cm, n = 98) for loggerheads, and 37.9 ± 15.1 cm (range: 15.6–80.6 cm, n = 64) for green turtles. Results of sex determination based on evaluation of gonads are provided in Table 3-3.

Table 3-1. Numbers of stranded sea turtles in Alabama, Mississippi, and Louisiana by species and 5-year period.

Species		Alabama	Mississippi	Louisiana	Total
Kemp's ridley					
	2010–2014	322 (15.5%)	1,071 (51.7%)	680 (32.8%)	2,073
	2015–2019	179 (20.6%)	469 (53.9%)	222 (25.5%)	870
	Total	501 (17.0%)	1,540 (52.3%)	902 (30.6%)	2,943
Loggerhead					
	2010–2014	37 (26.6%)	51 (36.7%)	51 (36.7%)	139
	2015–2019	54 (31.4%)	81 (47.1%)	37 (21.5%)	172
	Total	91 (29.3%)	132 (42.4%)	88 (28.3%)	311
Green turtle					
	2010–2014	21 (20.6%)	19 (18.6%)	62 (60.8%)	102
	2015–2019	25 (25.0%)	21 (21.0%)	54 (54.0%)	100
	Total	46 (22.8%)	40 (19.8%)	116 (57.4%)	202
Leatherback					
	2010–2014	3 (-)	1 (-)	3 (-)	7
	2015–2019	2 (-)	0 (-)	1 (-)	3
	Total	5 (50.0%)	1 (10.0%)	4 (40.0%)	10
Hawksbill					
	2010–2014	2 (-)	0 (-)	0 (-)	2
	2015–2019	0 (-)	0 (-)	0 (-)	0
	Total	2 (-)	0 (-)	0 (-)	2
Undetermined					
	2010–2014	20 (23.5%)	23 (27.1%)	42 (49.4%)	85
	2015–2019	10 (15.4%)	30 (46.2%)	25 (38.5%)	65
	Total	30 (20.0%)	53 (35.3%)	67 (44.7%)	150
All species					
	2010–2014	405 (16.8%)	1,164 (48.3%)	838 (34.8%)	2,408
	2015–2019	270 (22.3%)	601 (49.7%)	339 (28.0%)	1,210
	Total	675 (18.7%)	1,765 (48.8%)	1,177 (32.5%)	3,618

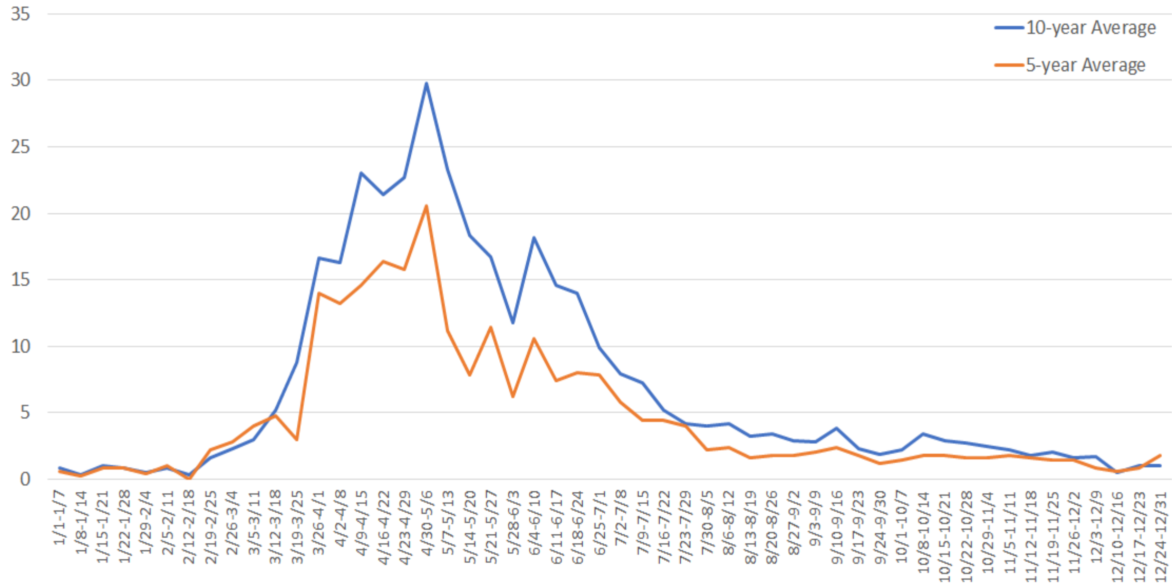


Figure 3-1. Average weekly stranding numbers for the northern Gulf of Mexico for 5-year (2015–2019) and 10-year (2010–2019) time frames.

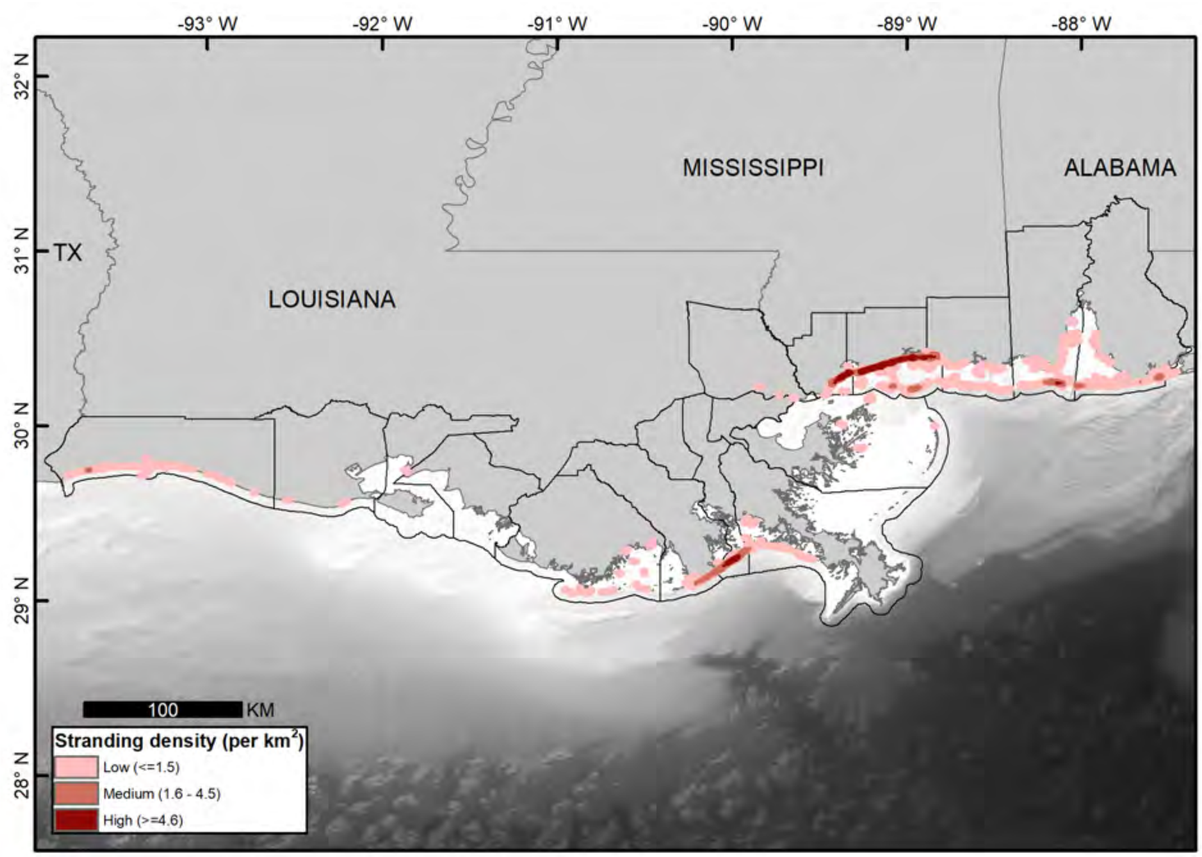


Figure 3-2. Density of all stranded turtles documented across the northern Gulf of Mexico during 2015–2019.

Table 3-2. Postmortem condition of stranded sea turtles from the northern Gulf of Mexico by species and 5-year period.

Species	Alive	Mildly decomposed	Moderately decomposed	Severely decomposed	Desiccated or skeletal remains	Unknown	Total
Kemp's ridley							
2010–2014	50 (2.4%)	65 (3.1%)	732 (35.3%)	1,005 (48.4%)	206 (9.9%)	15 (0.7%)	2,073
2015–2019	23 (2.6%)	17 (1.9%)	330 (37.9%)	421 (48.4%)	79 (9.1%)	0 (-)	870
Total	73 (2.5%)	82 (2.8%)	1,062 (36.1%)	1,426 (48.5%)	285 (9.7%)	15 (0.5%)	2,943
Loggerhead							
2010–2014	11 (7.9%)	10 (7.2%)	39 (28.1%)	59 (42.4%)	20 (14.4%)	0 (-)	139
2015–2019	12 (7.0%)	7 (4.1%)	49 (28.5%)	86 (50.0%)	16 (9.3%)	2 (1.2%)	172
Total	23 (7.4%)	17 (5.5%)	88 (28.3%)	145 (46.6%)	36 (11.6%)	2 (0.6%)	311
Green turtle							
2010–2014	5 (4.9%)	15 (14.7%)	33 (32.4%)	38 (37.3%)	10 (9.8%)	1 (1.0%)	102
2015–2019	11 (11.0%)	7 (7.0%)	42 (42.0%)	27 (27.0%)	13 (13.0%)	0 (-)	100
Total	16 (7.9%)	22 (10.9%)	75 (37.1%)	65 (32.2%)	23 (11.4%)	1 (0.5%)	202
Leatherback							
2010–2014	0 (-)	0 (-)	0 (-)	7 (-)	0 (-)	0 (-)	7
2015–2019	0 (-)	0 (-)	2 (-)	1 (-)	0 (-)	0 (-)	3
Total	0 (-)	0 (-)	2 (20.0%)	8 (80.0%)	0 (-)	0 (-)	10
Hawksbill							
2010–2014	2 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	2
2015–2019	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
Total	2 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	2
Undetermined							
2010–2014	4 (4.7%)	2 (2.4%)	4 (4.7%)	16 (18.8%)	28 (32.9%)	31 (36.4%)	85
2015–2019	1 (1.5%)	1 (1.5%)	5 (7.7%)	11 (16.9%)	20 (30.8%)	27 (41.5%)	65
Total	5 (3.3%)	3 (2.0%)	9 (6.0%)	27 (18.0%)	48 (32.0%)	58 (38.7%)	150
All species							
2010–2014	72 (3.0%)	92 (3.8%)	808 (33.6%)	1,125 (46.7%)	264 (11.0%)	47 (2.0%)	2,408
2015–2019	47 (3.9%)	32 (2.6%)	428 (35.4%)	546 (45.1%)	128 (10.6%)	29 (2.4%)	1,210
Total	119 (3.3%)	124 (3.4%)	1,236 (34.2%)	1,671 (46.2%)	392 (10.8%)	76 (2.1%)	3,618

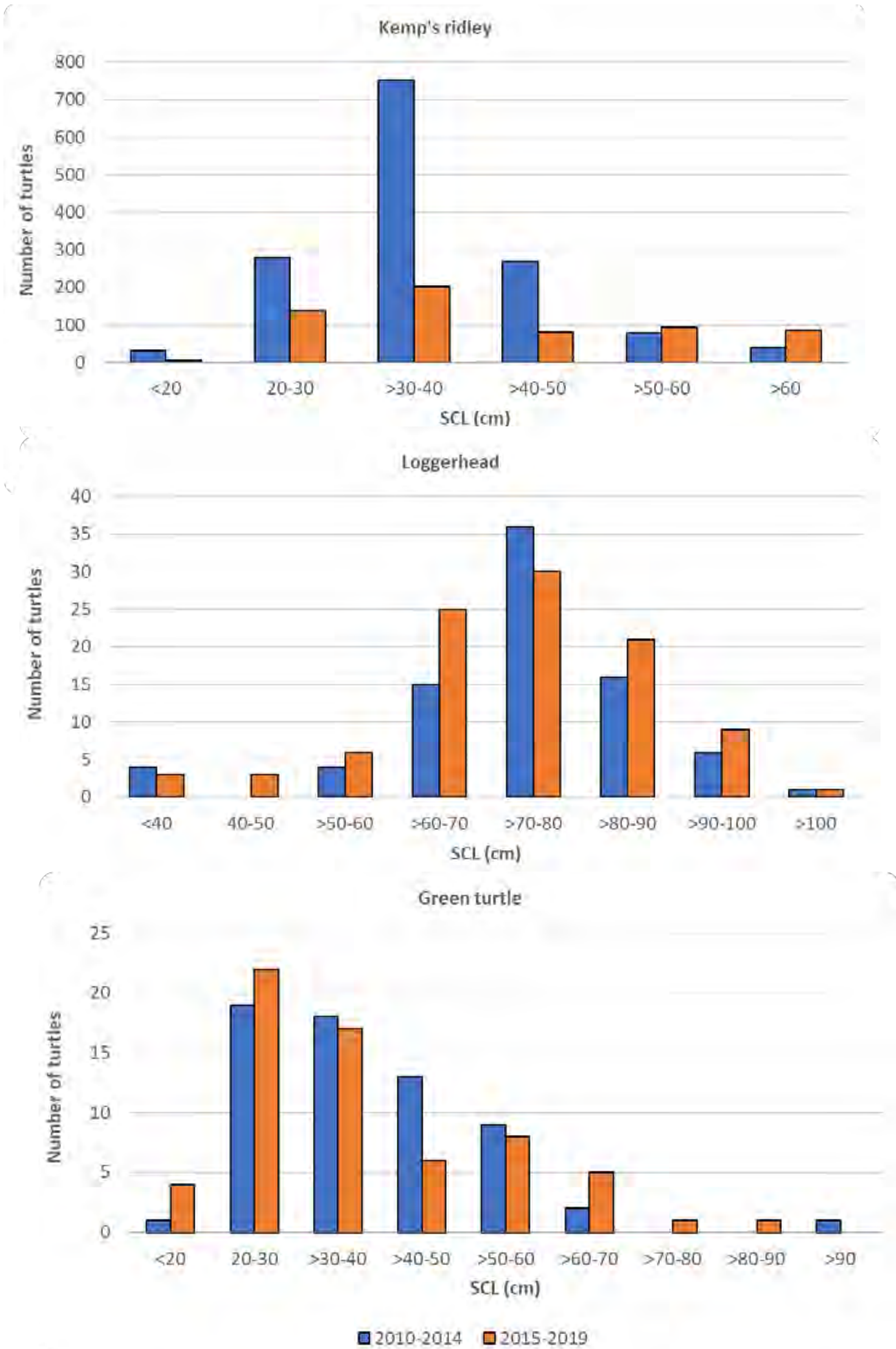


Figure 3-3. Histograms (by species) of straight carapace lengths (SCL) for sea turtles found stranded in Alabama, Mississippi, and Louisiana during 2010–2014 and 2015–2019. (SCL, measured from nuchal notch to caudal tip of the carapace)

Table 3-3. Sex of stranded sea turtles in Alabama, Mississippi, Louisiana by species and 5-year period based on gonadal examination.

Species	Alabama		Mississippi		Louisiana		NGOM Total	
	Female							
Kemp's ridley								
2010–2014	79 (64.7%)	43 (35.2%)	273 (69.1%)	122 (30.9%)	236 (66.8%)	117 (33.2%)	588 (67.6%)	282 (32.4%)
2015–2019	52 (69.3%)	23 (30.7%)	141 (68.1%)	66 (31.9%)	64 (66.7%)	32 (33.3%)	257 (68.0%)	121 (32.0%)
Total	131 (66.5%)	66 (33.5%)	414 (68.8%)	188 (31.2%)	300 (66.8%)	149 (33.2)	845 (67.7%)	403 (32.3%)
Loggerhead								
2010–2014	7 (-)	1 (-)	7 (-)	1 (-)	23 (95.8%)	1 (4.2%)	37 (92.5%)	3 (7.5%)
2015–2019	18 (94.7%)	1 (5.3%)	13 (86.6%)	2 (13.4%)	6 (60.0%)	4 (40.0%)	37 (84.1%)	7 (15.9%)
Total	25 (92.6%)	2 (7.4%)	20 (87.0%)	3 (13.0%)	29 (85.3%)	5 (14.7%)	74 (88.1%)	10 (11.9%)
Green turtle								
2010–2014	3 (-)	3 (-)	2 (-)	1 (-)	22 (81.5%)	5 (18.5%)	27 (75.0%)	9 (25.0%)
2015–2019	7 (-)	2 (-)	5 (-)	2 (-)	8 (53.4%)	7 (46.6%)	20 (64.5%)	11 (35.5%)
Total	10 (66.7%)	5 (33.3%)	7 (70.0%)	3 (30.0%)	30 (71.4%)	12 (28.6%)	47 (70.1%)	20 (29.9%)

Not included in this table are a single female hawksbill (Alabama) and male leatherback (Louisiana) that stranding during 2010-2014.

Stranding and necropsy findings

Reported strandings in which photographs and/or necropsy information were available for review and assignment of a stranding category are summarized in Suppl. Table B-1. Necropsies were performed on 42.9% (519/1,210) of stranded turtles found during 2015–2019. Categories of stranding and necropsy observations are presented by species in Table 3-4 and are shown graphically by the week in Suppl. Figure C-1. Examples of stranded sea turtles representing the three main stranding categories: (1) those without evident anomalies, (2) those with major injuries, and (3) those with indications of poor health/disease are shown in Figures 3-4 through 3-6.

Notable species differences were observed among proportions of stranded sea turtles found to have sediment within their respiratory tract and ingested finfish or penaeid shrimp. Sediment was found in the trachea/bronchi of more Kemp's ridleys (45.1%, 132/293) than loggerheads (27.5%, 11/40) or green turtles (25.8%, 8/31) (X^2(2, N = 364) = 7.89, p-value= .01) (Table 3-5). Fish were found in the GI tracts of 70.7% of Kemp's ridleys (246/348), which was more than either loggerhead (35.7%, 15/42) or green turtles (0%, 0/31) (Table 3-6). Shrimp ingestion was only noted in Kemp's ridleys

(4.6%, 16/345). Observations related to intra-respiratory sediment and GI contents are further considered in relation to other findings within the following sections.

Findings categories

No anomalies. Most of the Kemp's ridleys that stranded in 2015–2019 (58.1%, 517/890) did not have apparent abnormalities. Many (78.9%) of these turtles had sediment within the respiratory tract (either within the trachea/bronchi and/or lungs); 30.1% (77/256) had sediment within the lungs. The proportion of Kemp's ridleys with sediment in the trachea/bronchi and no other abnormalities was greater than those with major injuries or evidence of disease (X^2 (2, N = 293) = 9.39, *p*-value = .009). In addition, more Kemp's ridleys without apparent abnormalities had food items within their stomach (74.9%, 218/291) and more had ingested fish (73.3%; 222/303) than those within other stranding categories (X^2 (2, N = 348) = 7.55, *p*-value= .02). There was a significant association between fish ingestion and post-mortem condition of Kemp's ridleys without anomalies (X^2 (2, N = 302) = 29.89, *p*-value <.00001); most were found severely decomposed. In addition, fish was found most frequently in the GI tracts of Kemp's ridleys that stranded in Mississippi (81.1%, 146/180) but was a relatively frequent observation for Kemp's ridleys found in Alabama (43.4%, 23/53) and Louisiana (75.4%, 52/69) as well.

Almost one-third of stranded loggerheads (31.4%, 54/172) had no abnormalities. The digestive contents of 24 were examined; 14 had ingested fish (58.3%). Thirteen loggerheads (32.5%, 13/40) had sediment within the respiratory tract (either within the trachea/bronchi and/or lungs when the tract could be examined, i.e., was not decomposed).

There were 11 green turtles without an apparent stranding cause (11.0%, 11/100); 1 had sediment in the trachea/bronchi.

Trauma. Major injuries were the second most frequent finding category for Kemp's ridleys and loggerheads and the most frequent observation among stranded green turtles. The most common type of trauma observed across all species was vessel strike injuries, representing 72.7% (157/216) of all injuries documented. (Table 3-7).

Disease-related. The disease-related category was the least frequent finding (3.7%, 45/1,210) across the NGOM for all species combined. The principal general findings related to these cases are presented in Table 3-8. The majority of turtles characterized in this category were in diminished nutritional condition and/or had epibiota accumulation without evident cause. Specific details related to the findings of these few disease-related cases are presented in subsequent sections for each state.

Table 3-4. Predominant findings for stranded sea turtles from the northern Gulf of Mexico by species and 5-year period.

Species	No abnormalities	Major injuries	Disease-related	Oiled	Unclassified	Total
Kemp's ridley						
2010–2014	966 (46.6%)	462 (22.3%)	64 (3.1%)	10 (0.5%)	570 (27.5%)	2,072*
2015–2019	517 (59.4%)	134 (15.4%)	14 (1.6%)	0 (-)	205 (23.6%)	870
Total	1,483 (50.4%)	596 (20.3%)	78 (26.5%)	10 (.3%)	775 (26.3%)	2,943
Loggerhead						
2010–2014	24 (17.3%)	35 (25.2%)	17 (12.2%)	0 (-)	63 (45.3%)	139
2015–2019	54 (31.4%)	33 (19.2%)	24 (14.0%)	0 (-)	61 (35.5%)	172
Total	78 (25.1%)	68 (21.9%)	41 (13.2%)	0 (-)	124 (39.9%)	311
Green turtle						
2010–2014	7 (6.9%)	54 (53.5%)	4 (4.0%)	1 (1.0%)	35 (34.7%)	101*
2015–2019	22 (22.0%)	49 (49.0%)	7 (7.0%)	0 (-)	22 (22.0%)	100*
Total	29 (14.4%)	103 (51.0%)	11 (5.4%)	1 (0.5%)	57 (28.2%)	202
Leatherback						
2010–2014	2 (-)	3 (-)	0 (-)	0 (-)	2 (-)	7
2015–2019	2 (-)	0 (-)	0 (-)	0 (-)	1 (-)	3
Total	4 (40.0%)	3 (30.0%)	0 (-)	0 (-)	3 (30.0%)	10
Hawksbill						
2010–2014	0 (-)	0 (-)	1 (-)	0 (-)	1 (-)	2
2015–2019	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
Total	0	0	1	0	1	2
Undetermined						
2010–2014	0 (-)	0 (-)	0 (-)	0 (-)	85 (100%)	85
2015–2019	0 (-)	2 (3.0%)	0 (-)	0 (-)	63 (97.0%)	65
Total	0 (-)	2 (1.3%)	0 (-)	0 (-)	148 (98.7%)	150
All species						
2010–2014	999 (41.5%)	554 (23.0%)	86 (3.6%)	11 (0.5%)	756 (31.4%)	2,406
2015–2019	595 (49.2%)	218 (18.0%)	45 (3.7%)	0 (-)	352 (29.1%)	1,210
Total	1,594 (44.1%)	772 (21.3%)	131 (3.6%)	11 (0.3%)	1,108 (30.6%)	3,616

*Does not include single cold-stunned sea turtles in AL, MS, and LA.

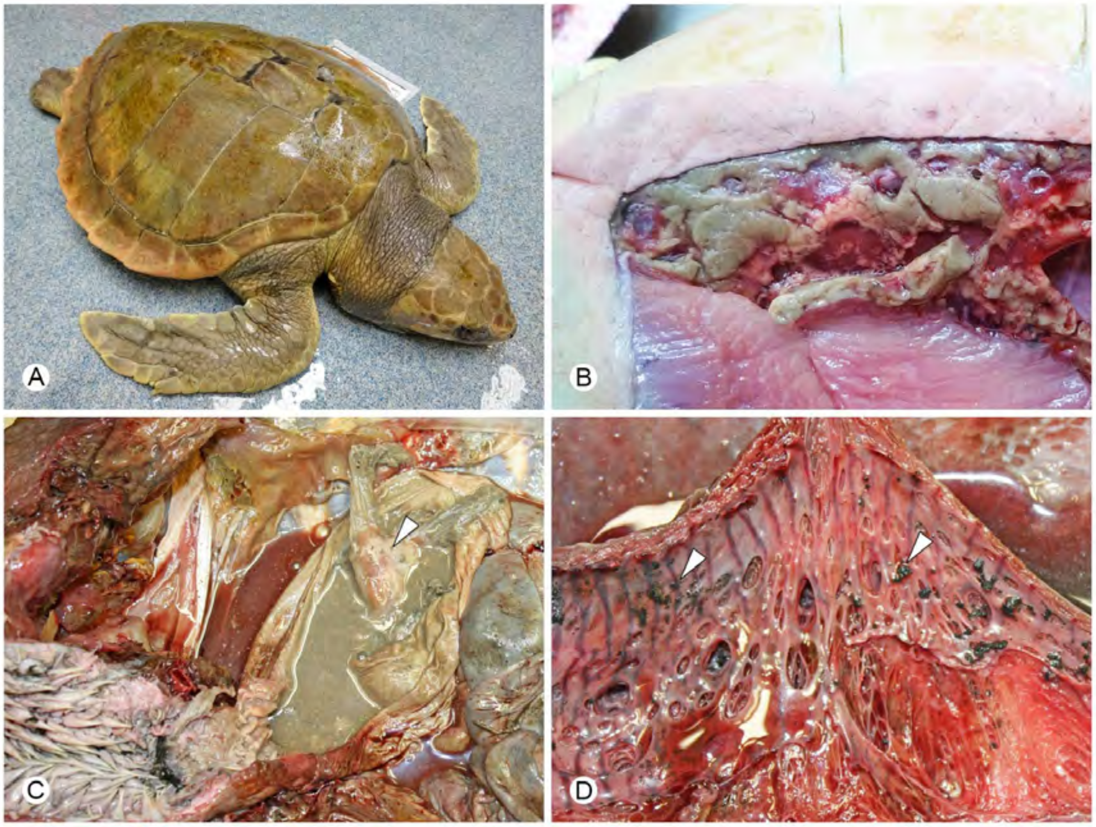


Figure 3-4. Examples of frequent findings in sea turtles categorized as "no anomalies" or evident cause of stranding (all shown are Kemp's ridleys) (current FWCC permit MTP21-08). A) Moderate decomposition, no injuries or other apparent abnormalities. B) Non-atrophied fat indicating good nutritional condition. C) Partially digested fish within the stomach; the tail of a large specimen (arrowhead) is visible in this example. D) Black sediment (arrowhead) within a lung suggestive of aspiration of sediment-rich drowning medium.

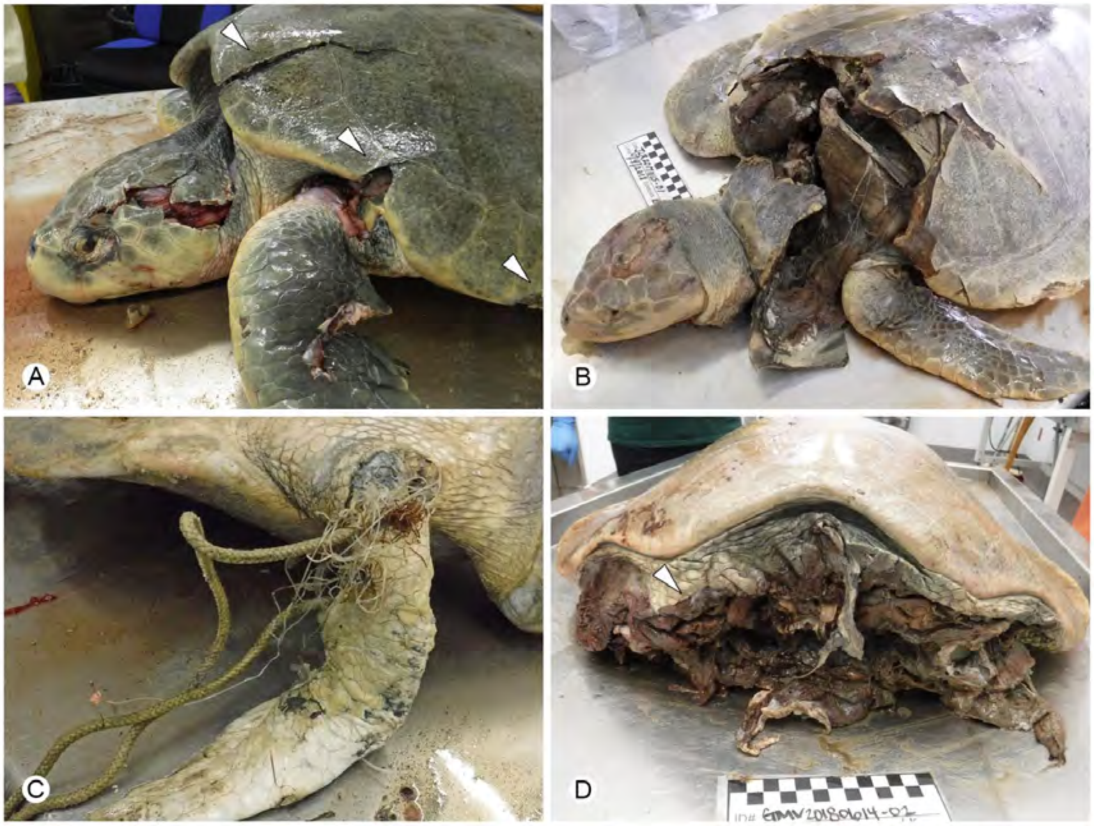


Figure 3-5. Examples of frequent findings in stranded sea turtles categorized as having major injuries (all shown are Kemp's ridleys) (current FWCC permit MTP21-08). A) Multiple chop wounds (arrowheads) are typical of trauma caused by a vessel propeller. B) Blunt force trauma consistent with an injury caused by collision with non-rotating vessel components. C) Entanglement in rope and monofilament line. D) Shark bites resulting in the removal of the head and front flippers. Note the sharp force injuries (arrowhead) created by shark teeth cleanly cutting through soft tissue.

Figure 3-6. Examples of findings in stranded sea turtles categorized as having evidence of "disease" or poor general health (current FWCC permit MTP21-08). A) Emaciated Kemp's ridley (gaunt neck and shoulders) with abnormally heavy algae growth on the carapace. One of the front flippers has been amputated by a shark bite. B) Severe atrophy of fat (loggerhead turtle) indicating diminished nutritional condition. C) Pale visceral organs (loggerhead turtle) indicating severe anemia. The liver and fat are also atrophied (poor nutritional condition). D) Ulcerative colitis (bacterial), a common abnormality in chronically ill loggerheads. E) Green turtle with impaction and obstruction of the cloaca and distal colon (arrowhead). F) Chronic inflammation of the bile ducts (arrowheads) in a loggerhead is associated with heavy parasitism by trematodes (inset, Calycodes anthos).

Table 3-5. Location of sediment within the respiratory tract for necropsied sea turtles from the northern Gulf of Mexico by species, 5-year period, and stranding category.

Species	Sediment in trachea/bronchi		Sediment in lungs	
Kemp's ridley				
No injuries	253/511 (49.5%)	124/256 (48.4%)	172/502 (34.3%)	77/256 (30.1%)
Trauma	31/157 (19.7%)	7/32 (21.9%)	20/157 (12.7%)	2/32 (6.3%)
Disease	13/37 (35.1%)	1/5 (-)	10/36 (27.8%)	1/5 (-)
Total	297/705 (42.1%)	132/293 (45.1%)	202/695 (29.1%)	80/293 (27.3%)
Loggerhead				
No injuries	4/12 (33.3%)	8/23 (34.8%)	5/12 (41.7%)	9/23 (39.1%)
Trauma	3/13 (23.1%)	1/2 (-)	1/13 (7.7%)	0/2 (-)
Disease	3/9 (-)	2/15 (13.3%)	3/9 (-)	4/15 (26.7%)
Total	10/34 (29.4%)	11/40 (27.5%)	9/34 (26.5%)	13/40 (32.5%)
Green turtle				
No injuries	1/4 (-)	1/10 (10.0%)	0/4 (-)	1/10 (10.0%)
Trauma	3/20 (15.0%)	7/17 (41.2%)	2/20 (10.0%)	2/17 (11.8%)
Disease	0/2 (-)	0/4 (-)	0/2 (-)	0/4 (-)
Total	4/26 (15.4%)	8/31 (25.8%)	2/26 (7.7%)	3/31 (9.7%)

Table 3-6. Digestive contents of stranded sea turtles from the northern Gulf of Mexico by species, 5-year period, and stranding category.

Species	Food in mouth or esophagus		Food in stomach		Ingested fish		Ingested shrimp	
Kemp's ridley								
No anomalies	129/649 (19.9%)	51/292 (17.5%)	485/608 (79.8%)	218/291 (74.9%)	527/643 (82.0%)	222/303 (73.3%)	59/621 (9.5%)	12/300 (4.0%)
Trauma	21/230 (9.1%)	8/38 (21.1%)	109/162 (67.3%)	22/38 (57.9%)	91/179 (50.8%)	21/39 (53.8%)	7/164* (4.3%)	4/39 (10.3%)
Disease	2/44 (4.5%)	1/6 (-)	23/44 (52.3%)	4/6 (-)	31/45 (68.9%)	3/6 (-)	2/43 (4.7%)	0/6 (-)
Total	152/923 (16.5%)	60/336 (17.9%)	617/814 (75.8%)	244/335 (72.8%)	649/867 (74.9%)	246/348 (70.7%)	68/828 (8.2%)	16/345 (4.6%)
Loggerhead								
No anomalies	4/14 (28.6%)	5/23 (21.7%)	8/14 (57.1%)	13/23 (56.5%)	8/17 (47.1%)	14/24 (58.3%)	0/15 (0%)	0/16 (0%)
Trauma	4/13 (30.8%)	0/2 (-)	4/12 (33.3%)	1/2 (-)	0/12 (0%)	0/2 (-)	0/12 (0%)	0/2 (-)
Disease	0/10 (0%)	0/16 (0%)	0/9 (-)	4/16 (25.0%)	1/9 (-)	1/16 (6.3%)	0/9 (-)	0/24 (0%)
Total	8/37 (21.6%)	5/41 (12.2%)	12/35 (34.3%)	18/41 (43.9%)	9/38 (23.7%)	15/42 (35.7%)	0/36 (0%)	0/42 (0%)
Green turtle								
No anomalies	4/6 (-)	7/10 (70.0%)	6/6 (-)	9/10 (90.0%)	0/6 (-)	0/10 (0%)	0/6 (-)	0/10 (0%)
Trauma	9/33 (27.3%)	11/17 (64.7%)	22/23 (95.7%)	14/15 (93.3%)	2/17 (11.8%)	0/17 (0%)	0/17 (0%)	0/17 (0%)
Disease	2/2 (-)	0/4 (-)	3/3 (-)	2/4 (-)	0/3 (-)	0/4 (-)	0/3 (-)	0/4 (-)
Total	15/41 (36.6%)	18/31 (58.1%)	31/32 (96.9%)	25/29 (86.2%)	2/26 (7.7%)	0/31 (0%)	0/26 (0%)	0/31 (0%)

*4 additional Kemp's ridleys had antennae suggestive of penaeid shrimp.

Table 3-7. Types of injuries observed in sea turtles found stranded in the northern Gulf of Mexico by species and 5-year period. Fishing tackle/gear includes hooking injuries, entanglements, and internal injuries from ingestion. Multiple injury types comprise turtles with shark bites in addition to vessel strike wounds or fishery interactions.

Species	Vessel strike	Fishing tackle/gear	Non-fisheries entangle / entrap	Shark bites	Multiple types	Other	Total
Kemp's ridley							
2010–2014	315 (68.2%)	30 (6.5%)	2 (0.4%)	66 (14.3%)	32 (6.9%)	17 (3.7%)	462
2015–2019	97 (72.4%)	12 (9.0%)	3 (2.2%)	13 (9.7%)	2 (1.5%)	7 (5.2%)	134
Total	412 (69.1%)	42 (7.0%)	5 (0.8%)	79 (13.3%)	34 (5.7%)	24 (4.0%)	596
Loggerhead							
2010–2014	17 (48.6%)	2 (5.7%)	1 (2.9%)	12 (34.3%)	1 (2.9%)	2 (5.7%)	35
2015–2019	22 (66.7%)	1 (3.0%)	0 (0%)	4 (12.1%)	0 (0%)	6 (18.2%)	33
Total	39 (57.4%)	3 (4.4%)	0 (0%)	16 (23.5%)	1 (1.5%)	8 (11.8%)	68
Green turtle							
2010–2014	46 (85.2%)	0 (0%)	0 (0%)	4 (7.4%)	4 (7.4%)	0 (0%)	54
2015–2019	38 (77.6%)	5 (10.2%)	2 (4.1%)	1 (2.0%)	0 (0%)	3 (6.1%)	49
Total	84 (81.6%)	5 (4.9%)	2 (1.9%)	5 (4.9%)	4 (3.9%)	3 (2.9%)	103
Leatherback							
2010–2014	3 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	3
2015–2019	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
Total	3 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	3
Hawksbill							
2010–2014	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
2015–2019	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
Total	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
All species							
2010–2014	381 (68.8%)	32 (5.8%)	3 (0.5%)	82 (14.8%)	37 (6.7%)	19 (3.4%)	554
2015–2019	157 (72.7%)	18 (8.3%)	5 (2.3%)	18 (8.3%)	2 (0.9%)	16 (7.4%)	216
Total	538 (69.9%)	50 (6.5%)	8 (1.0%)	100 (13.0%)	39 (5.1%)	35 (4.5%)	770

*Does not include single cold-stunned sea turtles in MS and LA.

Table 3-8. General findings of the disease-related category for necropsied turtles by state, 5-year period, and species. These turtles were in diminished nutritional condition and/or had findings indicative of a health condition(s) that may have contributed to stranding. Groupings in this table describe general post-mortem findings that best summarize each case based on additional detail found in individual necropsy reports.

State	Species	Diminished nutritional condition and/or epibiota accumulation	Inflammation or infection of one or more organs	Multifactorial (diminished nutritional condition and inflammation or infection)	Heavy parasitism
Alabama	2010–2014				
	Green turtle	1/1 (-)	(-)	(-)	(-)
	Kemp's ridley	3/8 (-)	5/8 (-)	(-)	(-)
	Loggerhead	6/7 (-)	1/7 (-)	(-)	(-)
	2015–2019				
	Green turtle	1/1 (-)	(-)	(-)	(-)
	Kemp's ridley	2/2 (-)	(-)	(-)	(-)
	Loggerhead	8/16 (50.0%)	2/16 (12.5%)	4/16 (25.0%)	2/16 (12.5%)
Mississippi	2010–2014				
	Green turtle	(-)	(-)	(-)	(-)
	Kemp's ridley	20/35 (57.1%)	12/35 (34.3%)	3/35 (8.6%)	(-)
	Loggerhead	2/4 (-)	(-)	2/4 (-)	(-)
	2015–2019				
	Green turtle	(-)	(-)	(-)	(-)
	Kemp's ridley	6/10 (60.0%)	(-)	4/10 (40.0%)	(-)
	Loggerhead	3/5 (-)	1/5 (-)	(-)	1/5 (-)
Louisiana	2010–2014				
	Green turtle	2/3(-)	1/3 (-)	0/3 (-)	(-)
	Kemp's ridley	13/21 (61.9%)	7/21 (33.3%)	1/21 (4.8%)	(-)
	Loggerhead	1/6	1/6	1/6	3/6
	2015–2019				
	Green turtle	5/6 (-)	1/6 (-)	(-)	(-)
	Kemp's ridley	2/2 (-)	(-)	(-)	(-)
	Loggerhead	2/3 (-)	1/3 (-)	(-)	(-)

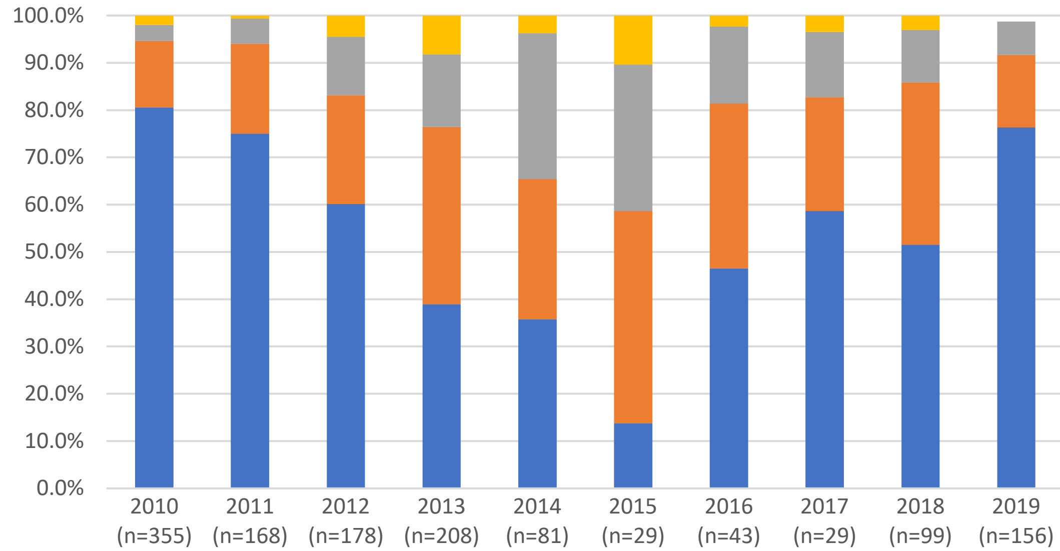
Nutritional condition

The fat evaluation results for Kemp's ridleys, loggerheads, and green turtles are shown in Tables 3-9 through 3-11. The Kemp's ridley was the only species with a sufficiently robust sample size to compare fat condition over time and by state and size class (Figure 3-7). A trend in reduced robustness of fat stores was evident from 2010 through 2015 and then reversed through 2019. Notably, those years with the greatest proportions of Kemp's ridleys with atrophied fat also had relatively low sample sizes. Due to the low numbers of observations for some years, we combined data for 5-year periods (2010–2014 and 2015–2019) to examine nutritional state over a broader temporal scale. The X^2 test of independence did not indicate an association between fat score and the 5-year period when all three states were combined. However, when values for individual states were compared by 5-year period, Kemp's ridleys that stranded in Louisiana within the most recent 5-years were more likely to have atrophied fat (X^2 (3, N = 505) = 8.48, p-value = .04). This difference

Table 3-9. Fat condition of necropsied Kemp's ridley turtles by state, 5-year period, and season (spring = March–May; summer = June–August).

State		No atrophy	Mild atrophy	Moderate atrophy	Severe atrophy	Total
Alabama						
	2010–2014	104 (68.4%)	27 (17.8%)	13 (8.6%)	8 (5.3%)	152
	2015–2019	45 (60.0%)	18 (24.0%)	8 (10.7%)	4 (5.3%)	75
	Total	149 (65.6%)	45 (19.8%)	21 (9.3%)	12 (5.3%)	227
Mississippi						
	2010–2014	249 (59.4%)	92 (22.0%)	58 (13.8%)	20 (4.8%)	419
	2015–2019	120 (61.5%)	51 (26.2%)	21 (10.8%)	3 (1.5%)	195
	Total	369 (60.1%)	143 (23.3%)	79 (12.9%)	23 (3.7%)	614
Louisiana						
	2010–2014	276 (65.9%)	106 (25.3%)	29 (6.9%)	8 (1.9%)	419
	2015–2019	46 (53.5%)	24 (27.9%)	13 (15.1%)	3 (3.5%)	86
	Total	322 (63.8%)	130 (25.7%)	42 (8.3%)	11 (2.2%)	505
All states – 5-yr period						
	2010–2014	629 (63.5%)	225 (22.7%)	100 (10.1%)	36 (3.6%)	990
	2015–2019	211 (59.3%)	93 (26.1%)	42 (11.8%)	10 (2.8%)	356
	Total	840 (62.4%)	318 (23.6%)	142 (10.5%)	46 (3.4%)	1,346
All states - season						
	Spring	483 (57.4%)	228 (27.1%)	103 (12.2%)	27 (3.2%)	841
	Summer	277 (72.3%)	65 (17.0%)	25 (6.5%)	16 (4.2%)	383

primarily reflected higher proportions of juvenile turtles (>25 - 45 cm SCL) with atrophied fat; fat condition was not significantly different between periods for Kemp's ridleys under 25 cm or greater than 45 cm SCL. Sample size should also be noted for this observation; fewer Kemp's ridleys were documented in Louisiana in 2015–2019 (n=86) compared to the previous 5-year period (n=419). There was no significant difference in fat condition between 5-year periods for Kemp's ridleys that stranded in Mississippi and Alabama.



	2010 (n=355)	2011 (n=168)	2012 (n=178)	2013 (n=208)	2014 (n=81)	2015 (n=29)	2016 (n=43)	2017 (n=29)	2018 (n=99)	2019 (n=156)
Severe atrophy	2.0%	0.6%	4.5%	8.2%	3.7%	10.3%	2.3%	3.4%	3.0%	0.0%
Moderate atrophy	3.4%	5.4%	12.4%	15.4%	30.9%	31.0%	16.3%	13.8%	11.1%	7.1%
Mild atrophy	14.1%	19.0%	23.0%	37.5%	29.6%	44.8%	34.9%	24.1%	34.3%	15.4%
No atrophy	80.6%	75.0%	60.1%	38.9%	35.8%	13.8%	46.5%	58.6%	51.5%	76.3%

Figure 3-7. Fat condition of Kemp's ridley turtles found stranded in Alabama, Mississippi, and Louisiana during 2010–2019. Degree of atrophy was evaluated based on photographs of pericoelomic fat taken during necropsy.

There was a significant association between fat condition and season of stranding (X^2 (3, N = 1,224) = 29.6, p-value < .001). Higher proportions of Kemp's ridleys stranded in March through May had mildly or moderately atrophied fat compared to those stranded June through August. Proportions with severely atrophied fat were similarly low in both seasons (3.2% and 4.2%, respectively). The seasonal difference in fat condition was primary due to strandings in Mississippi; fat condition did not vary significantly by season when Louisiana and Alabama data were compared separately.

Table 3-10. Fat condition of necropsied Kemp's ridley turtles from Louisiana by straight carapace length (SCL) and 5-year period. (SCL, nuchal notch to caudal tip)

SCL	No atrophy	Mild atrophy	Moderate atrophy	Severe atrophy	Total
≤25 cm					
2010–2014	59 (68.6%)	21 (24.4%)	5 (5.8%)	1 (1.2%)	86
2015–2019	7 (50.0%)	4 (28.6%)	3 (21.4%)	0 (0%)	14
25-45 cm					
2010–2014	141 (60.3%)	70 (29.9%)	17 (7.3%)	6 (2.6%)	234
2015–2019	7 (25.0%)	11 (39.3%)	8 (28.6%)	2 (7.1%)	28
>45 cm					
2010–2014	76 (76.8%)	15 (15.2%)	7 (7.1%)	1 (1.0%)	99
2015–2019	31 (72.1%)	9 (20.9%)	2 (4.7%)	1 (2.3%)	43

Table 3-11. Fat condition of stranded loggerhead and green turtles from the northern Gulf of Mexico by species and 5-year period.

Species	No atrophy	Mild atrophy	Moderate atrophy	Severe atrophy	Total
Loggerhead					
2010–2014	9 (90.0%)	0 (0%)	0 (0%)	1 (10.0%)	10
2015–2019	22 (53.7%)	7 (17.1%)	4 (9.8%)	8 (19.5%)	41
Total	31 (60.8%)	7 (13.7%)	4 (7.8%)	9 (17.6%)	51
Green turtle					
2010–2014	2 (-)	2 (-)	3 (-)	1 (-)	8
2015–2019	19 (50.0%)	7 (25.0%)	7 (25.0%)	5 (12.5%)	38
Total	21 (45.7%)	9 (19.6%)	10 (21.7%)	6 (13.0%)	46

3.2 Alabama sea turtle strandings

During 2015–2019, 270 stranded sea turtles were documented in Alabama (Suppl. Table B-2). Stranding data are presented by species and condition in Suppl. Table B-3. A map of stranding locations is provided in Suppl. Figure C-2. The average weekly stranding numbers for the 5-year and 10-year averages followed seasonal trends, with most strandings occurring in spring and summer (Fig. 3-8). Reports included 179 Kemp's ridleys, 54 loggerheads, 25 green turtles, 2 leatherbacks, and 10 sea turtles that could not be identified to species.

Total statewide strandings (n = 270) decreased by 33.3% from the previous 5-year total of 405 strandings, reflecting a 44.4% reduction in stranded Kemp's ridley turtles from 322 to 179 between the two time periods. Loggerhead and green turtle strandings were higher in the most recent 5-year period by 45.9% (17 additional loggerheads) and 19.0% (4 additional stranded green turtles).

Sea turtle strandings were documented along Alabama's entire coastline during 2015–2019, particularly beaches that are most accessible for detection (Suppl. Figure C-5). Kemp's ridley strandings occurred throughout Gulf-facing beaches and to a lesser extent in the inshore areas. Loggerhead strandings distribution was shifted eastward to the Gulf of Mexico shoreline of Baldwin County. Green turtle strandings were centered on Perdido Pass with some reports on Gulf-facing beaches across both counties. One of the stranded leatherbacks was located on Dauphin Island's shoreline, and the second was floating in the NGOM approximately 7 km south of Dauphin Island.

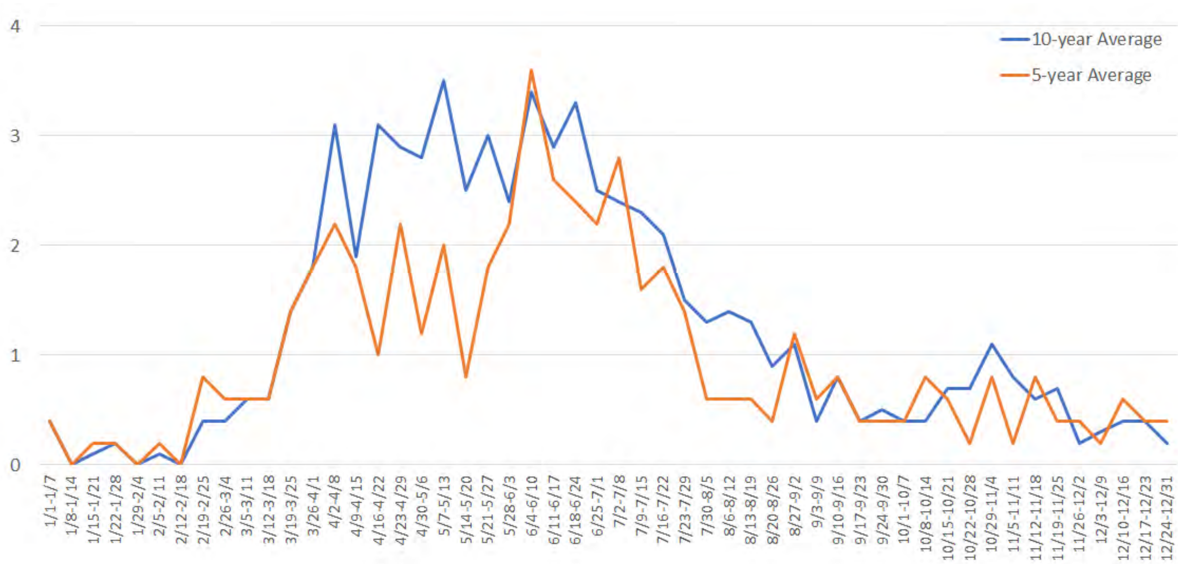


Figure 3-8. Average weekly stranding numbers for Alabama for 5-year and 10-year time frames.

We identified three distinct locations with the highest densities of sea turtle strandings during 2015–2019 (n=288): eastern Dauphin Island, Ft. Morgan Peninsula, and Perdido Pass (Fig. 3-9). These locations also had high stranding densities throughout the previous 5-year period (Fig. 3-9). During 2010–2014, stranding density was also high along the western Mobile Bay shoreline, but not in 2015–2019.

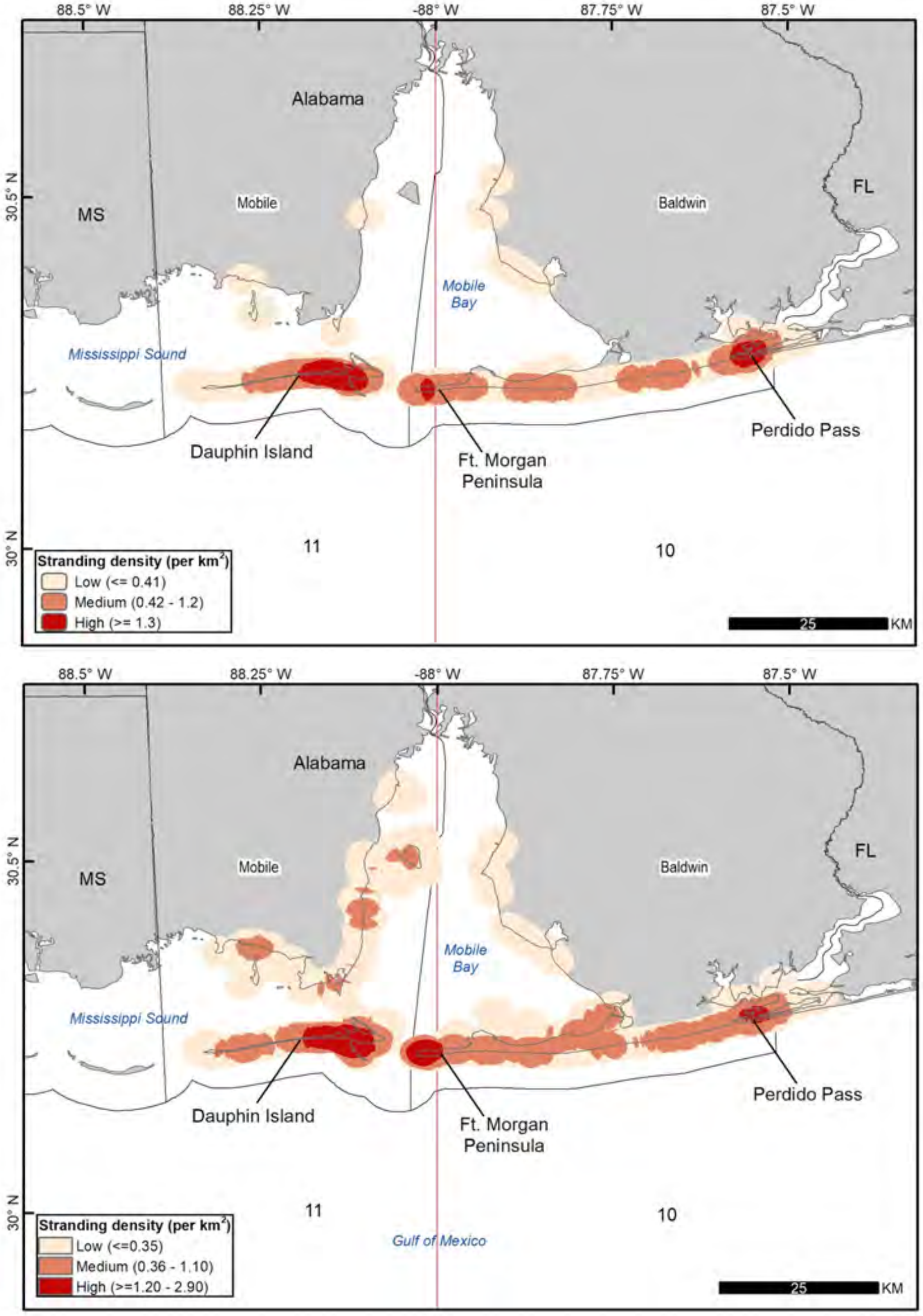


Figure 3-9. Density of sea turtle strandings documented by the Alabama STSSN during 2010–2014 (upper) and 2015–2019 (lower). During both 5-year periods, high densities of sea turtle strandings were observed at three locations: eastern Dauphin Island, Ft. Morgan Peninsula, and Perdido Pass.

The vast majority of Kemp's ridleys, loggerheads, and green turtles were found dead (74.0%, 94.5%, and 87.0%, respectively). Most Kemp's ridleys were moderately (41.3%, 74/179) or severely decomposed (40.8%, 73/179). The majority of loggerheads (42/54; 77.8%) and green turtles (17/25; 68.0%) also were moderately or severely decomposed.

Histograms of the SCL of stranded turtles are shown by species in Figure 3-10. Mean SCL for Kemp's ridley turtles was 41.8 ± 13.0 cm (range: 18.0–67.8 cm, n = 129), 72.0 ± 17.5 cm (range: 11.8–100.5 cm, n = 46) for loggerheads, and 40.7 ± 12.2 cm (mean ± one standard deviation [SD], range: 21.0–66.8 cm, n = 19) for green turtles. Two dead leatherback turtles and no hawksbills were documented as traditional strandings in 2015–2019.

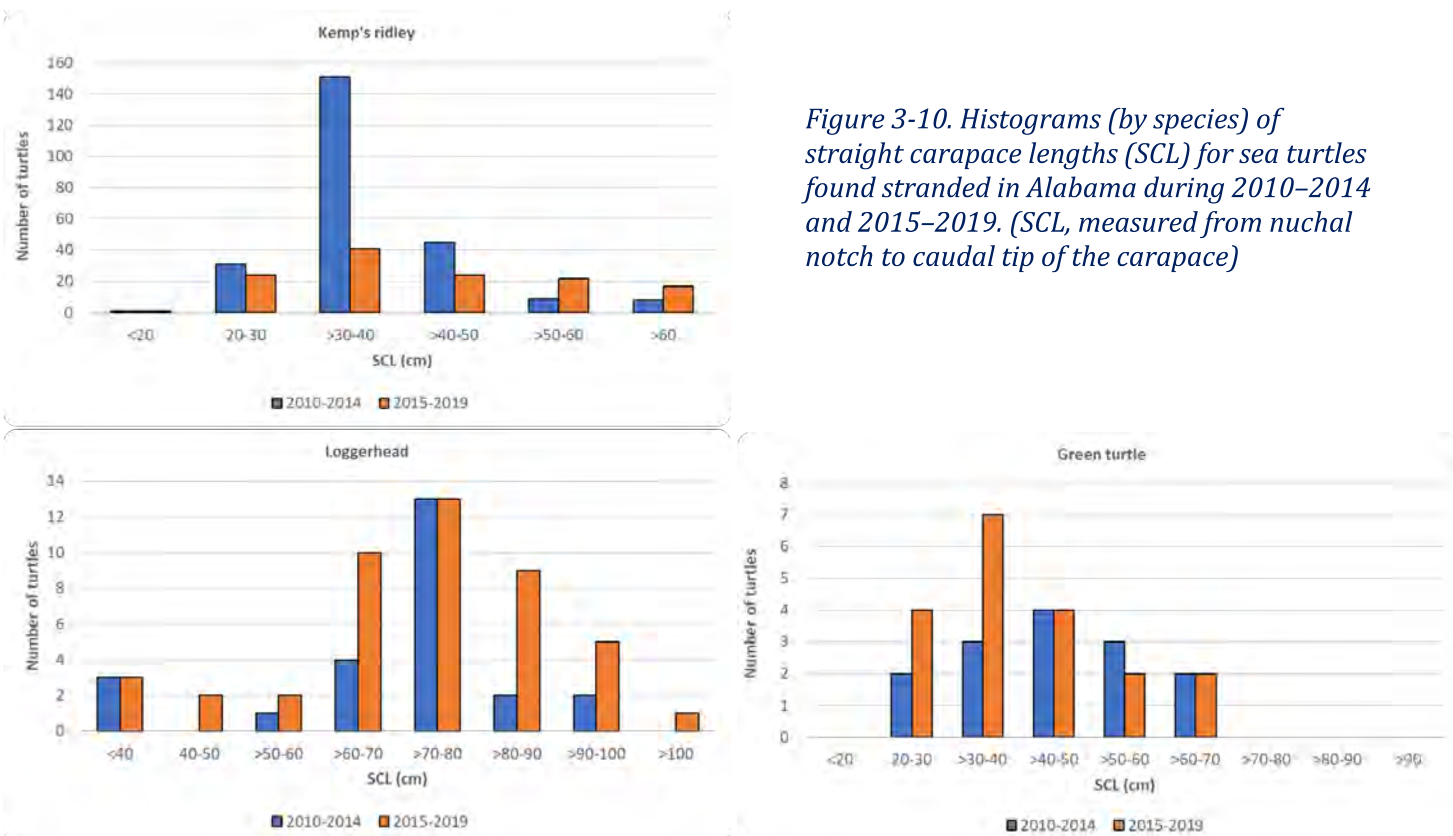


Figure 3-10. Histograms (by species) of straight carapace lengths (SCL) for sea turtles found stranded in Alabama during 2010–2014 and 2015–2019. (SCL, measured from nuchal notch to caudal tip of the carapace)

Table 3-12. Predominant findings of stranded sea turtles from Alabama by species and 5-year period.

Species		No abnormalities	Major injuries	Disease-related	Oiled	Unclassified	Total
Kemp's ridley							
	2010–2014	126 (39.1%)	109 (33.9%)	8 (2.5%)	2 (0.6%)	77 (23.9%)	322
	2015–2019	102 (57.0%)	45 (25.1%)	2 (1.1%)	0 (0%)	30 (16.8%)	179
	Total	228 (45.5%)	154 (30.7%)	10 (2.0%)	2 (0.4%)	101 (20.2%)	501
Loggerhead							
	2010–2014	6 (16.2%)	10 (27.0%)	7 (18.9%)	0 (0%)	14 (37.8%)	37
	2015–2019	19 (35.2%)	13 (24.1%)	16 (29.6%)	0 (0%)	6 (11.1%)	54
	Total	25 (27.5%)	23 (25.3%)	23 (25.3%)	0 (0%)	20 (22.0%)	91
Green turtle							
	2010–2014	0 (0%)	12 (57.1%)	1 (4.8%)	1 (4.8%)	7 (33.3%)	21*
	2015–2019	4 (16.0%)	18 (72.0%)	1 (4.0%)	0 (0%)	2 (8.0%)	25
	Total	4 (8.7%)	30 (65.2%)	2 (4.3%)	1 (2.2%)	9 (19.6%)	46
Leatherback							
	2010–2014	0 (-)	1 (-)	0 (-)	0 (-)	2 (-)	3
	2015–2019	1 (-)	0 (-)	0 (-)	0 (-)	1 (-)	2
	Total	1 (-)	1 (-)	0 (-)	0 (-)	3 (-)	5
Hawksbill							
	2010–2014	0 (-)	0 (-)	1 (-)	0 (-)	1 (-)	2
	2015–2019	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
	Total	0 (-)	0 (-)	1 (-)	0 (-)	1 (-)	2
Undetermined							
	2010–2014	0 (-)	0 (-)	0 (-)	0 (-)	20 (-)	20
	2015–2019	0 (-)	0 (-)	0 (-)	0 (-)	10 (-)	10
	Total	0 (-)	0 (-)	0 (-)	0 (-)	30 (100%)	30
All species							
	2010–2014	132 (32.6%)	132 (32.6%)	17 (4.2%)	3 (0.7%)	121 (29.9%)	405
	2015–2019	126 (46.7%)	76 (28.1%)	19 (7.0%)	0 (0%)	49 (18.1%)	270
	Total	258 (38.2%)	208 (30.8%)	36 (5.3%)	3 (0.4%)	170 (25.2%)	675

Stranding and necropsy findings

Necropsy was performed on 44.4% (107/241) of stranded turtles found in Alabama (Suppl. Table B-2). Detailed summaries related to intra-respiratory sediment and GI content observations are provided in Suppl. Tables B-4 and B-5, respectively.

Findings categories

Documentation and post-mortem condition was sufficient to assign a findings category for 81.9% (221/270) of strandings in Alabama; 18.1% (49/270) of strandings were unclassified. Categories of stranding and necropsy observations are presented by species in Table 3-12 and are shown graphically by the week in Suppl. Figure C-3.

No anomalies. The most frequent finding among stranded Kemp's ridleys in 2015–2019 was no evident abnormalities (57.0%, 102/179). The majority of these turtles stranded in spring (48.0%, 86/179) and summer months (40.2%, 72/179). Of the Kemp's ridleys without abnormalities that were necropsied, almost half (49.0%, 24/49) had sediment within the respiratory tract (either within the trachea/bronchi and/or lungs) (Suppl. Table B-4), and the GI contents included fish in 23 cases (39.0%, 23/59) (Suppl. Table B-5). Over a third of loggerheads (35.2%, 19/54) were also stranded with no evident abnormalities. Eight loggerheads with no anomalies were examined internally, one was found to have fish in the digestive tract, and one had sediment within the respiratory tract. There were 4 stranded green turtles without an obvious cause (16.0%, 4/25), and only one had sediment in the airway.

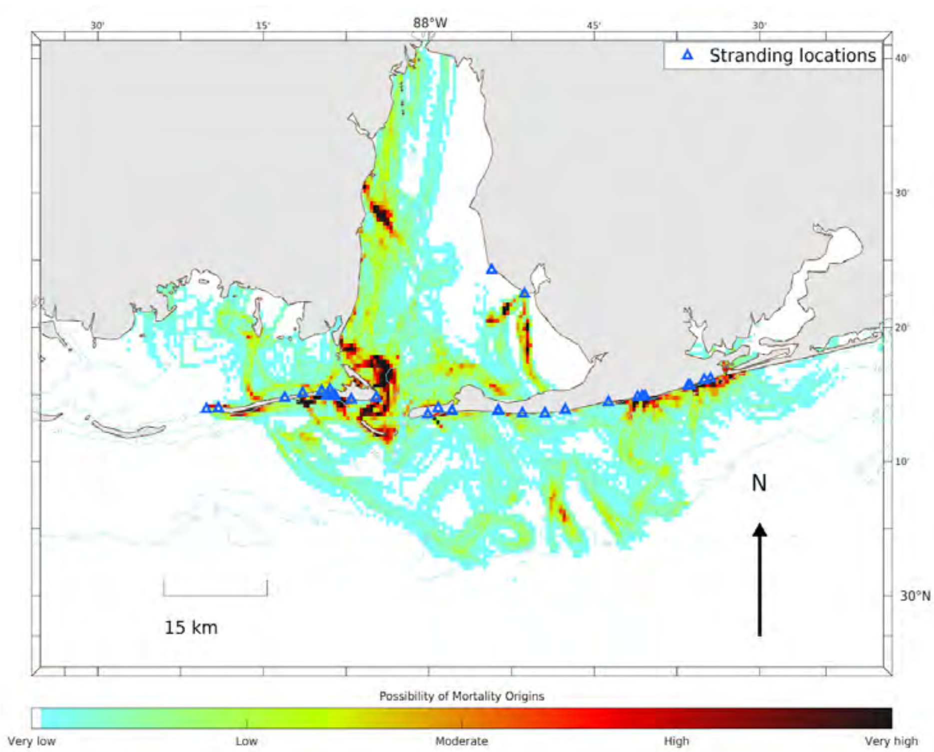
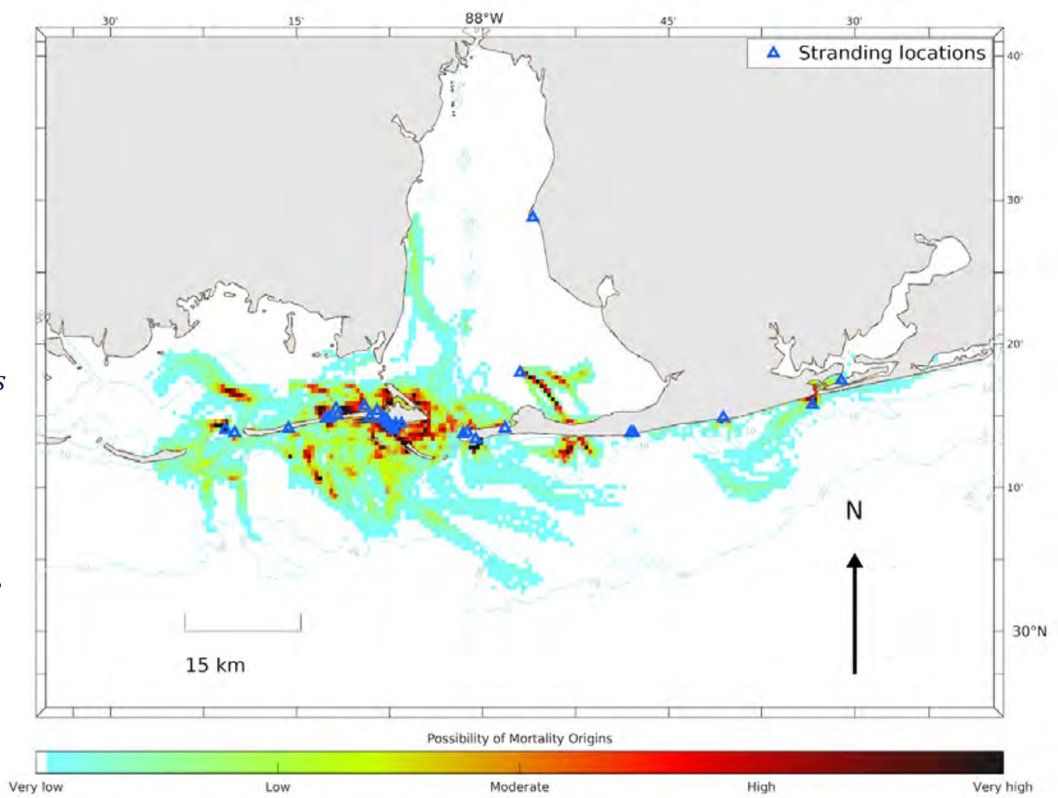


Figure 3-11. Heat map showing the locations where turtles with no abnormalities may have died in Alabama. This map is derived from the cumulative result of backtracking analysis using the stranding locations (blue triangles) as input. Represented are 32 turtles located from 2017–2019 that were found stranded during the spring season (March through May).

The probable locations of mortality for a subset of turtles from this group (58 Kemp's ridleys, 10 loggerheads, and 4 green turtles) were determined using backtracking analysis. Seasonal groupings of these turtles by spring and summer months highlighted possible concentrated areas where death may have occurred (Figs. 3-11, 3-12). Several possible mortality locations in the spring included the nearshore areas of Dauphin Island (Pelican Bay, East and Northeast side), Mobile Bay, Gulf Shores, and Orange Beach (Perdido Pass). Throughout the summer months, mortality locations were centered more around Dauphin Island's nearshore waters, within 10 km.

Figure 3-12. Heat map showing the locations where turtles with no abnormalities may have died in Alabama. This map is derived from the cumulative result of backtracking analysis using the stranding locations (blue triangles) as input. Represented are 31 turtles located from 2017–2019 that were found stranded during the summer season (June through August).



Trauma. Trauma was the second most common stranding finding among stranded Kemp's ridleys and loggerheads and the most common finding among stranded green turtles found in Alabama. Collectively, vessel strikes were the leading cause of trauma for all sea turtle species in Alabama (61.8%; 47/76) (Table 3-13). The next most frequent injury type found in Kemp's ridleys and green turtles was trauma caused by fishing-related materials. Shark bite wounds were the second most frequent injury type identified in loggerheads.

Table 3-13. Types of injuries observed in sea turtles found stranded in Alabama by species and 5-year period. Fishing tackle/gear includes hooking injuries, entanglements, and internal injuries from ingestion. Multiple injury types comprise turtles with shark bites in addition to vessel strike wounds or fishery interactions.

Species	Vessel strike	Fishing tackle/gear	Non-fisheries entangle / entrap	Shark bites	Multiple types	Other	Total
Green turtle							
2010–2014	12 (100.0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	12
2015–2019	14 (77.8%)	3 (16.7%)	0 (0%)	0 (0%)	0 (0%)	1 (5.6%)	18
Total	26 (86.7%)	3 (10.0%)	0 (0%)	0 (0%)	0 (0%)	1 (3.3%)	30
Kemp's ridley							
2010–2014	60 (55.0%)	12 (11.0%)	1 (0.9%)	17 (15.6%)	9 (8.3%)	10 (9.2%)	109
2015–2019	27 (60.0%)	6 (13.3%)	2 (4.4%)	5 (11.1%)	1 (2.2%)	4 (8.9%)	45
Total	87 (56.5%)	18 (11.7%)	3 (1.9%)	22 (14.3%)	10 (6.5%)	14 (9.1%)	154
Loggerhead							
2010–2014	5 (50.0%)	0 (0%)	0 (0%)	3 (30.0%)	1 (10.0%)	1 (10.0%)	10
2015–2019	6 (46.2%)	0 (0%)	0 (0%)	4 (30.8%)	0 (0%)	3 (23.1%)	13
Total	11 (47.8%)	0 (0%)	0 (0%)	7 (30.4%)	1 (4.3%)	4 (17.4%)	23
Hawksbill							
2010–2014	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)
2015–2019	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)
Total	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)
Leatherback							
2010–2014	1 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	1 (-)
2015–2019	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)
Total	1 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	1 (-)
All species							
2010–2014	78 (59.1%)	12 (9.1%)	1 (0.8%)	20 (15.2%)	10 (7.6%)	11 (8.3%)	132
2015–2019	47 (61.8%)	9 (11.8%)	2 (2.6%)	9 (11.8%)	1 (1.3%)	8 (10.5%)	76
Total	125 (60.1%)	21 (10.1%)	3 (1.4%)	29 (13.9%)	11 (5.3%)	19 (9.1%)	208

Disease-related. Those strandings with evidence of disease were the least frequent category of stranding for Kemp's ridleys and green turtles but accounted for 29.6% (16/54) of loggerhead strandings in Alabama. Findings in these loggerheads included various degrees of weight loss and accumulation of epibiota, parasitism, and internal infections. Of those turtles necropsied, one loggerhead suffered from a chronic infection of the bile ducts that contributed to emaciation and death. One turtle died from asphyxiation resulting from a severe infection of the trachea (windpipe). Two loggerheads in thin nutritional condition were noted to have relatively intense endoparasitism, including spirorchiid trematode (blood fluke) infection involving the brain (neurospirorchiidiasis). Four loggerheads were reported to have multiple processes that contributed to stranding, including emaciation, ulcerative GI disease, and septicemia. In addition, one of the loggerhead turtles had impaction of the colon from ingested sponge resulting in secondary infection of the bowel and septicemia. Two Kemp's ridleys had indications of poor health, including emaciation and accumulated epibiota. A primary cause of these conditions was not identified. Other findings among stranded turtles within the disease category included fibropapillomatosis, which was documented in one green turtle and one Kemp's ridley. The green turtle had several fibropapilloma tumors on the axillary and inguinal regions and the plastron. The Kemp's ridley stranded alive with fibropapillomas and was entangled in discarded monofilament fishing line. These were the only incidences of fibropapillomatosis documented among traditional strandings within the NGOM during 2015–2019.

3.3 Mississippi sea turtle strandings

During 2015–2019, 601 stranded sea turtles were documented in Mississippi (Suppl. Table B-6. Stranding data are presented by species and condition in Suppl. Table B-7. A map of stranding locations is provided in Suppl. Figure C-4. The average weekly stranding numbers for the 5-year and 10-year averages exhibited the aforementioned seasonal pattern (Fig. 3-13). Reports included 469 Kemp's ridleys, 81 loggerheads, 21 green turtles, and 30 sea turtles that could not be identified to species.

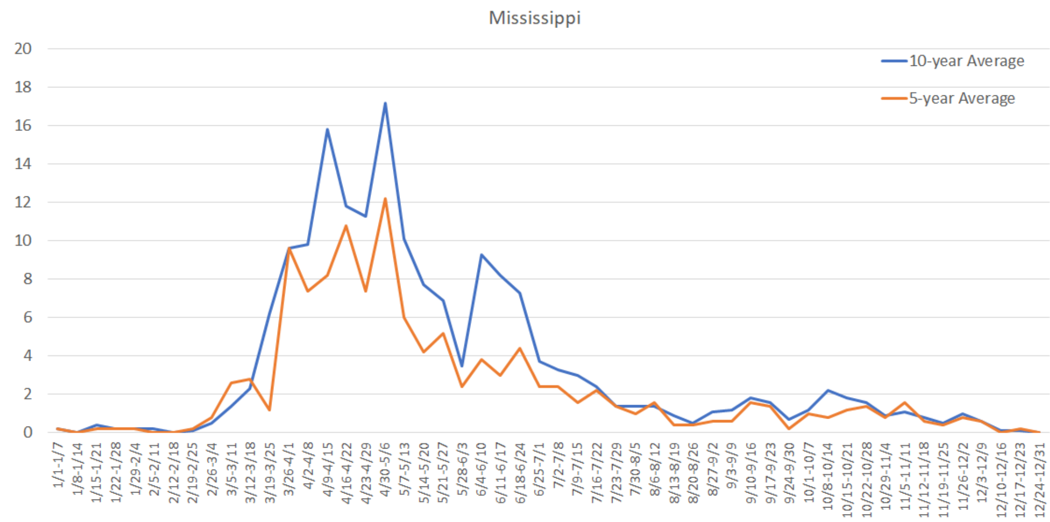


Figure 3-13. Average weekly stranding numbers for Mississippi for 5-year and 10-year time frames.

Total statewide strandings (n = 601) decreased by 48.4% from the previous 5-year total of 1,164 strandings. Furthermore, the mainland strandings decreased over time, from 926 turtles to 395 turtles (57.3% decrease). Strandings decreased by 59.5% on mainland beaches in Harrison County from 637 to 258 turtles due to a 56.2% reduction in the number of stranded Kemp's ridley turtles from 1,071 to 469 between these periods. In contrast, loggerhead and green turtle strandings increased during the 2015–2019 timeframe by 70.8% and 16.7%, respectively, increasing the number of stranded loggerheads from 48 to 82.

Most sea turtle strandings were documented along Mississippi's mainland beaches throughout 2015–2019 (Table 3-14). We found no difference in the spatial distribution of stranding locations in Mississippi during the 5-year reporting period. However, the proportion of stranding reports from the Mississippi barrier islands increased from the previous 5-year average of 13.1% to 26.4%, while reports from the marsh/sound (~7%) remained proportionately consistent. This more frequent reporting on barrier islands comprised an approximately 10% increase by species (Kemp's ridleys, loggerheads, and green turtles) compared to the previous 5 years.

Table 3-14. Sea turtle strandings in Mississippi 2010–2019 by location category. Corresponding proportions for each species are given in parentheses.

Species		Mainland	Barrier Islands	Marsh/Sound	Total
Kemp's ridley					
	2010–2014	873 (81.8%)	117 (11.0%)	77 (7.2%)	1067
	2015–2019	338 (72.5%)	96 (20.6%)	32 (6.9%)	466
	Total	1211 (79.0%)	213 (13.9%)	109 (7.1%)	1533
Loggerhead					
	2010–2014	27 (56.3%)	17 (35.4%)	4 (8.3%)	48
	2015–2019	38 (46.3%)	38 (46.3%)	6 (7.3%)	82
	Total	65 (50.0%)	55 (42.3%)	10 (7.7%)	130
Green turtle					
	2010–2014	12 (66.7%)	4 (22.2%)	2 (11.1%)	18
	2015–2019	12 (57.1%)	7 (33.3%)	2 (9.5%)	21
	Total	24 (61.5%)	11 (28.2%)	4 (10.3%)	39
Leatherback					
	2010–2014	0 (-)	1 (-)	0 (-)	1 (-)
	2015–2019	0 (-)	0 (-)	0 (-)	0 (-)
	Total	0 (-)	1 (-)	0 (-)	1 (-)
Undetermined					
	2010–2014	14 (46.7%)	14 (46.7%)	2 (6.7%)	30
	2015–2019	7 (24.1%)	17 (58.6%)	5 (17.2%)	29
	Total	21 (35.6%)	31 (52.5%)	7 (11.9%)	59
All species					
	2010–2014	926 (79.6%)	153 (13.1%)	85 (7.3%)	1164
	2015–2019	395 (66.1%)	158 (26.4%)	45 (7.5%)	598
	Total	1321 (75.0%)	311 (17.7%)	130 (7.4%)	1762

We identified four distinct locations along the northern Mississippi Sound shoreline with high densities of sea turtle strandings during 2015–2019 (n=598): one location in Hancock County, near Bay St. Louis, and four locations in Harrison County (Fig. 3-14). Areas of high-density strandings were spatially larger throughout the preceding 5-year period but found along similar portions of the northern Mississippi Sound shorelines of Hancock and Harrison counties (Fig. 3-14).

The vast majority of Kemp's ridleys, loggerheads, and green turtles were found dead (98.1%, 97.5%, and 95.2%, respectively), and most were moderately or severely decomposed. Histograms of the SCL of stranded turtles are shown by species in Figure 3-15. Mean SCL for Kemp's ridley turtles was 39.5 ± 12.3 cm (range: 19.6–66.5 cm, n = 328), 72.3 ± 11.0 cm (range: 49.2–92.6 cm, n =28) for loggerheads, and 40.6 ± 19.5 cm (mean ± one standard deviation [SD] for green turtles. No leatherback or hawksbill turtles were documented as traditional strandings in Mississippi during 2015–2019.

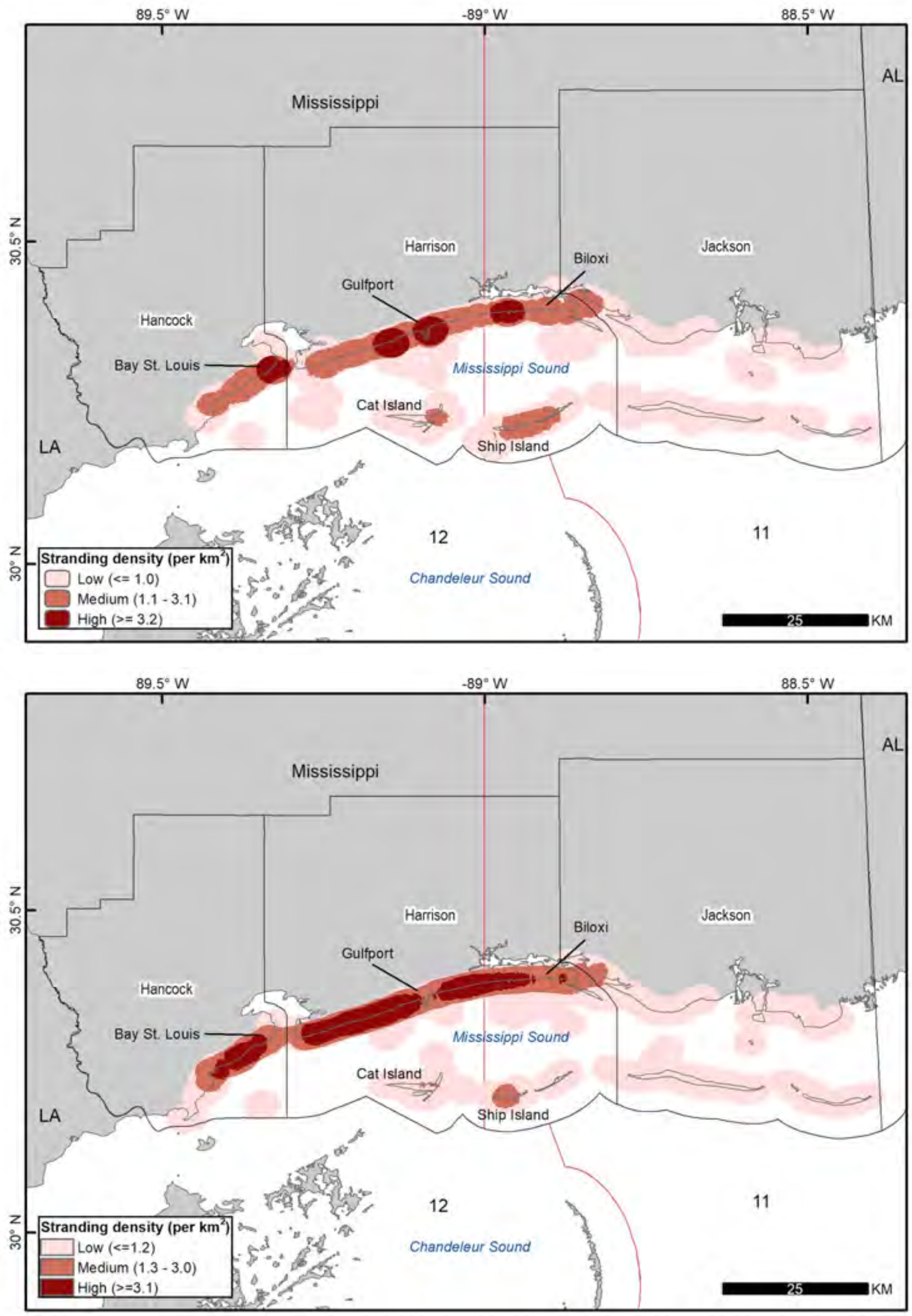


Figure 3-14. Density of sea turtle strandings documented by the Mississippi STSSN during 2010–2014 (upper image) and 2015–2019 (lower image). High densities of sea turtle strandings were observed along broad portions of the northern Mississippi Sound shorelines of Hancock and Harrison counties.

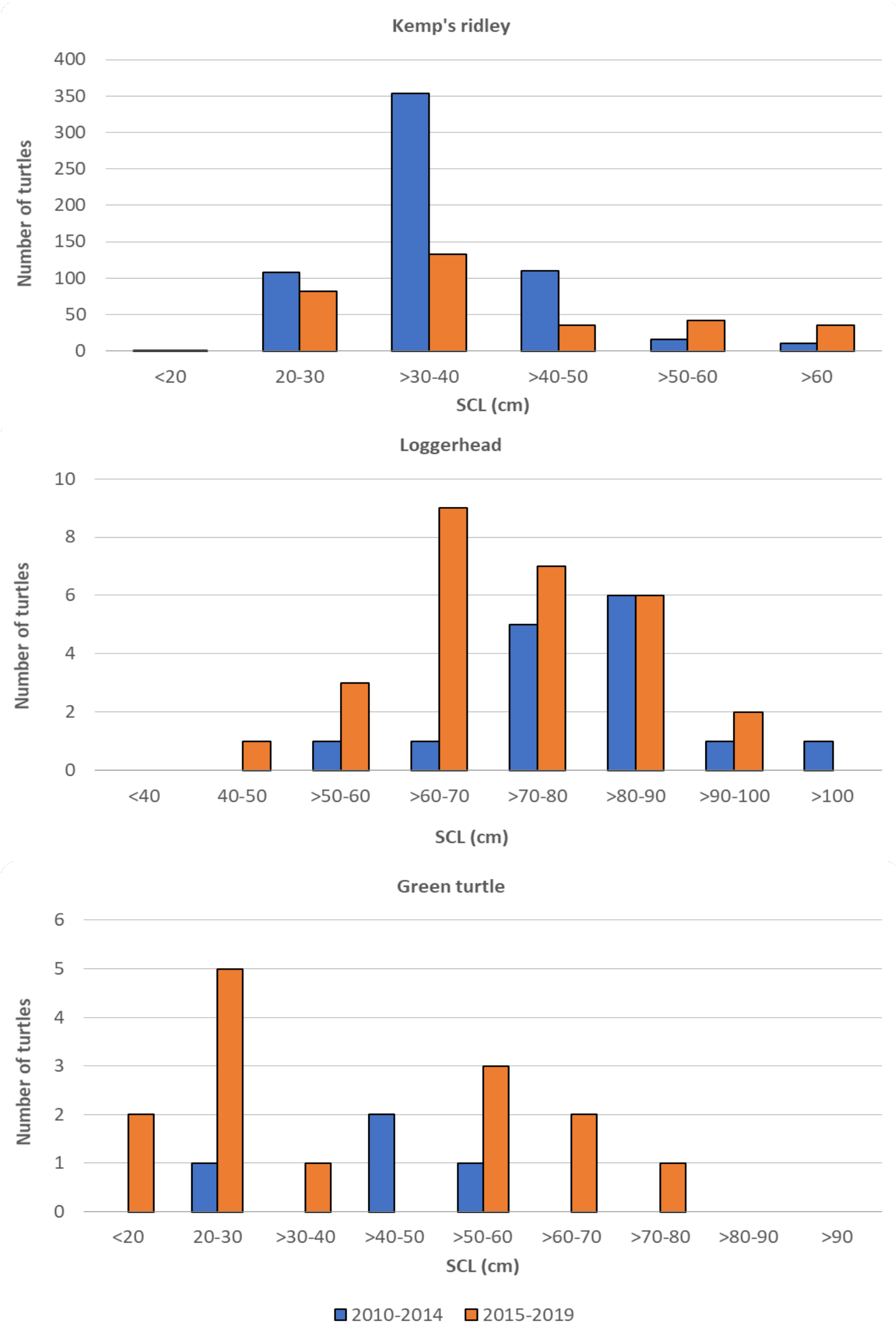


Figure 3-15. Histograms (by species) of straight carapace lengths (SCL) for sea turtles found stranded in Mississippi during 2010–2014 and 2015–2019. (SCL, measured from nuchal notch to caudal tip of the carapace).

Stranding and necropsy findings

Necropsy was performed on 41.9% (244/582) of stranded turtles that were found dead, and an additional turtle found alive that later died (Suppl. Table B-6). Observations related to sediment within the respiratory system and GI contents are presented in Suppl. Tables B-8 and B-9, respectively, and are discussed with concurrent findings in the following sections.

Table 3-15. Necropsy findings of stranded sea turtles from Mississippi by species and 5-year period.

Species	No abnormalities	Major injuries	Disease- related	Oiled	Unclassified	Total
Kemp's ridley						
2010–2014	550 (51.4%)	203 (19.0%)	35 (3.3%)	0 (0%)	283 (26.4%)	1,071
2015–2019	311 (66.3%)	62 (13.2%)	10 (2.1%)	0 (0%)	86 (18.3%)	469
Total	861 (55.8%)	265 (17.2%)	45 (2.9%)	0 (0%)	369 (23.9%)	1,540
Loggerhead						
2010–2014	6 (11.8%)	15 (29.4%)	4 (7.8%)	0 (0%)	26 (51.0%)	51
2015–2019	22 (27.2%)	14 (17.3%)	5 (6.2%)	0 (0%)	40 (49.4%)	81
Total	28 (21.2%)	29 (22.0%)	9 (6.8%)	0 (0%)	66 (50.0%)	132
Green turtle						
2010–2014	0 (0%)	12 (66.7%)	1 (5.3%)	0 (0%)	6 (33.3%)	19*
2015–2019	9 (42.9%)	8 (38.1%)	0 (0%)	0 (0%)	4 (19.0%)	21
Total	9 (22.5%)	20 (50.0%)	0 (0%)	0 (0%)	10 (25.0%)	40
Leatherback						
2010–2014	0 (-)	1 (-)	0 (-)	0 (-)	0 (-)	1
2015–2019	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
Total	0 (-)	1 (-)	0 (-)	0 (-)	0 (-)	1
Hawksbill						
2010–2014	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
2015–2019	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
Total	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
Undetermined						
2010–2014	0 (0%)	0 (0%)	0 (0%)	0 (0%)	23 (100%)	23
2015–2019	0 (0%)	2 (6.7%)	0 (0%)	0 (0%)	28 (93.3%)	30
Total	0 (0%)	2 (3.8%)	0 (0%)	0 (0%)	51 (96.2%)	53
All species						
2010–2014	556 (47.8%)	231 (19.8%)	40 (3.4%)	0 (0%)	338 (29.0%)	1,165
2015–2019	342 (56.9%)	86 (14.3%)	15 (2.5%)	0 (0%)	158 (26.3%)	601
Total	898 (50.9%)	317 (18.0%)	55 (3.1%)	0 (0%)	496 (28.1%)	1,766

*Does not include a single cold-stunned green turtle.

Findings categories

Nearly 74% (443 /601) of strandings in Mississippi could be assigned a findings category based on the study criteria. The 26.2% (158/601) that could not be classified were primarily due to advanced decomposition and included 49.4% (40/81) of stranded loggerheads. Categories of stranding and necropsy observations are presented by species in Table 3-14 and are shown graphically by the week in Suppl. Figure C-5.

No anomalies. Most stranded Kemp's ridleys (66.3%, 311/469) did not have any evident abnormalities. Most of these turtles were moderately (49.2%, 153/311) or severely (48.2%, 150/311) decomposed. Over half (64.6%, 106/164) of them had sediment within their respiratory tract (either within the trachea/bronchi and/or lungs) (Suppl. Table B-8), and 81.1% had been feeding on finfish, which was a significantly higher proportion than those that had major injuries or evidence of disease (X^2(2, N=197) =8.86, p-value= .01) (Suppl. Table B-9). Twenty-seven percent of loggerheads also did not have any apparent abnormalities (27.2%; 22/81). Of those that were necropsied, 7/14 had sediment within their respiratory tract, and 9/10 had ingested fish. Notably, 42.9% (9/21) of green turtle standings did not have any evident abnormalities.

The probable locations of mortality for a subset of 220 turtles from this group (198 Kemp's ridleys, 14 loggerheads, and 7 greens) were determined using backtracking analysis. We observed seasonal differences in the distribution of predicted mortality locations. In the spring, locations with the greatest probability of mortality were concentrated in the western and central Mississippi Sound (Fig. 3-16). Predicted mortality locations were more scattered throughout the summer months and were both within and outside the Mississippi Sound (Fig. 3-17).

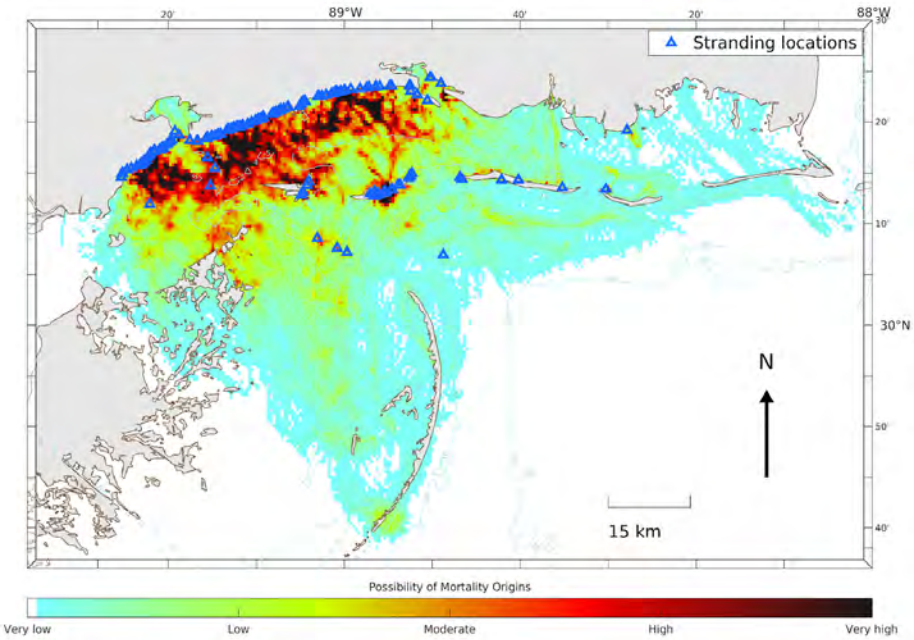
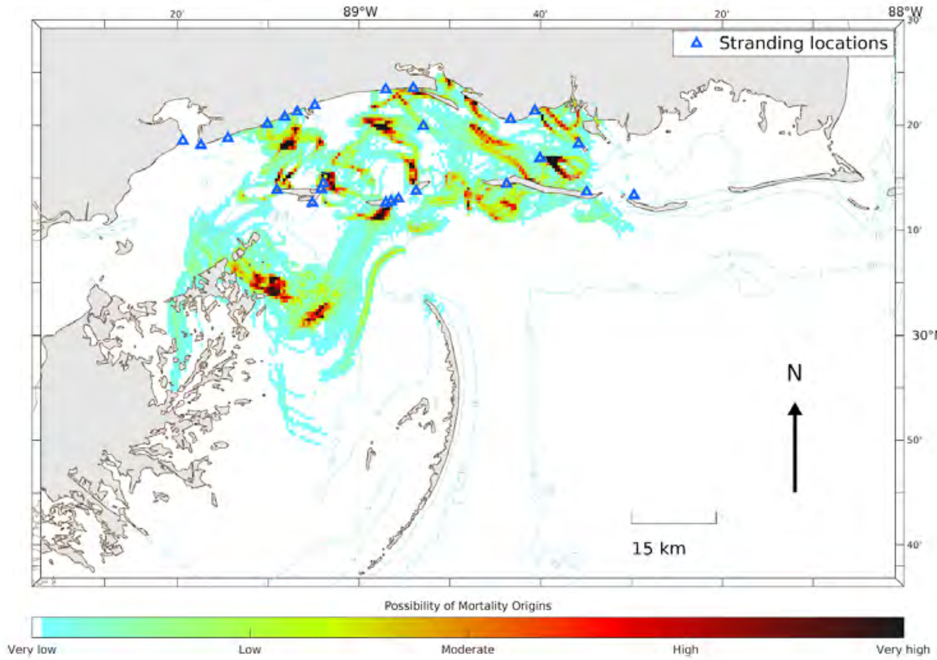


Figure 3-16. Heat map showing the locations where turtles with no abnormalities may have died in Mississippi. This map is derived from the cumulative result of backtracking analysis using the stranding locations (blue triangles) as input. Represented are 182 turtles located from 2017–2019 that were found stranded during the spring season (March through May).

Figure 3-17. Heat map showing the locations where turtles with no abnormalities may have died in Mississippi. This map is derived from the cumulative result of backtracking analysis using the stranding locations (blue triangles) as input. Represented are 25 turtles located from 2017–2019 that were found stranded during the summer season (June through August).



Trauma. Strandings with major injuries comprised the second most frequent category for all species. Vessel strike injuries were the most common type of trauma observed in Kemp's ridleys (83.9%, 52/62), loggerheads (92.9%, 13/14), and green turtles (6/8) (Table 3-16). Collectively, vessel strikes were the leading cause of trauma in all sea turtle species in Mississippi (83.7%; 72/86). The next most frequent injury type (9.7%; 6/62) found in Kemp's ridleys was from trauma caused by fishing-related materials.

Disease-related. Very few (2.5%; 15/601) stranded sea turtles found in Mississippi had evidence of significant disease. Ten Kemp's ridleys and 5 loggerheads had indications of poor health, including emaciation and accumulated epibiota. One of the loggerheads in this disease category had a colonic obstruction caused by a large mass of ingested marine sponges. Another loggerhead turtle had a probable bacterial infection involving the nervous system. Two Kemp's ridleys within this category had chronic abscesses within the gular region suggestive of prior trauma from fish hooks or other penetrating injuries. However, this finding was not believed to have contributed to stranding. Both of these turtles had food within their GI tracts, indicating they were foraging near the time of death.

Table 3-16. Types of injuries observed in sea turtles found stranded in Mississippi by species and 5-year period. Fishing tackle/gear includes hooking injuries, entanglements, and internal injuries from ingestion. Multiple injury types comprise turtles with shark bites in addition to vessel strike wounds or fishery interactions.

Species	Vessel strike	Fishing tackle/gear	Non-fisheries entangle / entrap	Shark bites	Multiple types	Other	Total
Kemp's ridley							
2010–2014	152 (74.9%)	14 (6.9%)	1 (0.5%)	21 (10.3%)	11 (5.4%)	4 (2.0%)	203
2015–2019	52 (83.9%)	6 (97%)	1 (1.6%)	1 (1.6%)	1 (1.6%)	1 (1.6%)	62
Total	204 (77.0%)	20 (7.5%)	2 (0.8%)	22 (8.3%)	12 (4.5%)	5 (1.9%)	265
Loggerhead							
2010–2014	9 (60.0%)	1 (6.7%)	1 (6.7%)	4 (26.7%)	0 (0%)	0 (0%)	15
2015–2019	13 (92.9%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (7.1%)	14
Total	22 (84.6%)	1 (3.4%)	1 (3.4%)	4 (13.8%)	0 (0%)	1 (3.4%)	29
Green turtle							
2010–2014	11 (91.7%)	0 (0%)	0 (0%)	0 (0%)	1 (8.3%)	0 (-)	12
2015–2019	6 (-)	0 (-)	1 (-)	0 (-)	0 (-)	1 (-)	8
Total	17 (85.0%)	0 (0%)	1 (5.0%)	0 (0%)	1 (5.0%)	1 (5.0%)	20
Leatherback							
2010–2014	1 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	1
2015–2019	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
Total	1 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	1
Hawksbill							
2010–2014	1 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	1
2015–2019	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
Total	1 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	1
All species							
2010–2014	173 (74.9%)	15 (6.5%)	2 (0.9%)	25 (10.8%)	12 (5.2%)	4 (1.7%)	231
2015–2019	72 (83.7%)	6 (7.0%)	2 (2.3%)	1 (1.2%)	1 (1.2%)	4 (4.7%)	86
Total	245 (77.3%)	21 (6.6%)	4 (1.3%)	26 (8.2%)	13 (4.1%)	8 (2.5%)	317

3.4 Louisiana sea turtle strandings

During 2015–2019, 339 stranded sea turtles were documented in Louisiana (Suppl. Table B-10). The average weekly stranding numbers for the 5-year and 10-year averages exhibited strong seasonality peaking throughout the spring months (Fig. 3-18). Stranding data are presented by species and condition in Suppl. Table B-11. A map of stranding locations in Louisiana is provided in Suppl. Figure C-6. Reports included 222 Kemp's ridleys, 37 loggerheads, 54 green turtles, 1 leatherback, and 25 sea turtles that could not be identified to species.

Total statewide strandings (n = 339) decreased by 59.5% from the previous 5-year total (n = 838). As in other NGOM states, this reduction was mostly due to a 67.4% decrease in stranded Kemp's ridleys from 680 strandings documented in 2010–2014 to 222 in 2015–2019. Loggerhead strandings decreased slightly by 8.1% between the 5-year periods (2010–2014, n=37; 2015–2019, n=34). There was a mild increase in green turtle strandings from 48 to 54 reports (12.5%) during the most recent 5-year period.

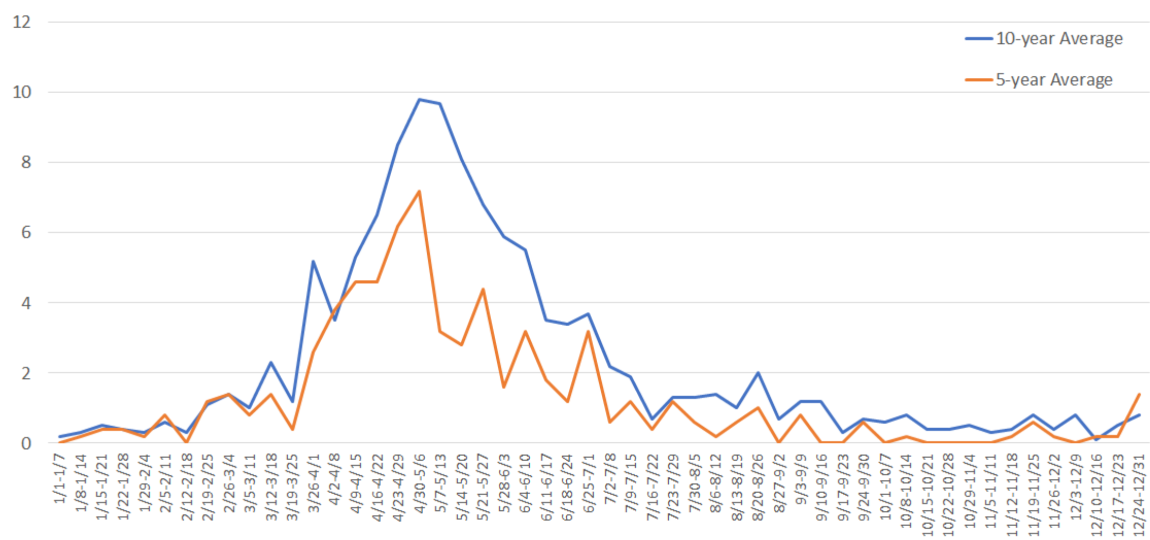


Figure 3-18. Average weekly stranding numbers for Louisiana for 5-year and 10-year time frames.

Sea turtle strandings were primarily documented along the most accessible and highly frequented beaches of the western and eastern Louisiana coast during 2015–2019 (Suppl. Figure C-7). Kemp's ridley and loggerhead strandings were more broadly distributed within the state. Green turtle strandings were primarily found within eastern Louisiana parishes of Terrebonne, Jackson, Jefferson, and Plaquemines. The highest density of sea turtle strandings in Louisiana throughout 2015–2019 occurred on Grand Isle, the most consistently surveyed area (Fig. 3-19). During the preceding 5-year period, stranding densities were similar, with high densities near Grand Isle in 2010–2014 (Fig. 3-19).

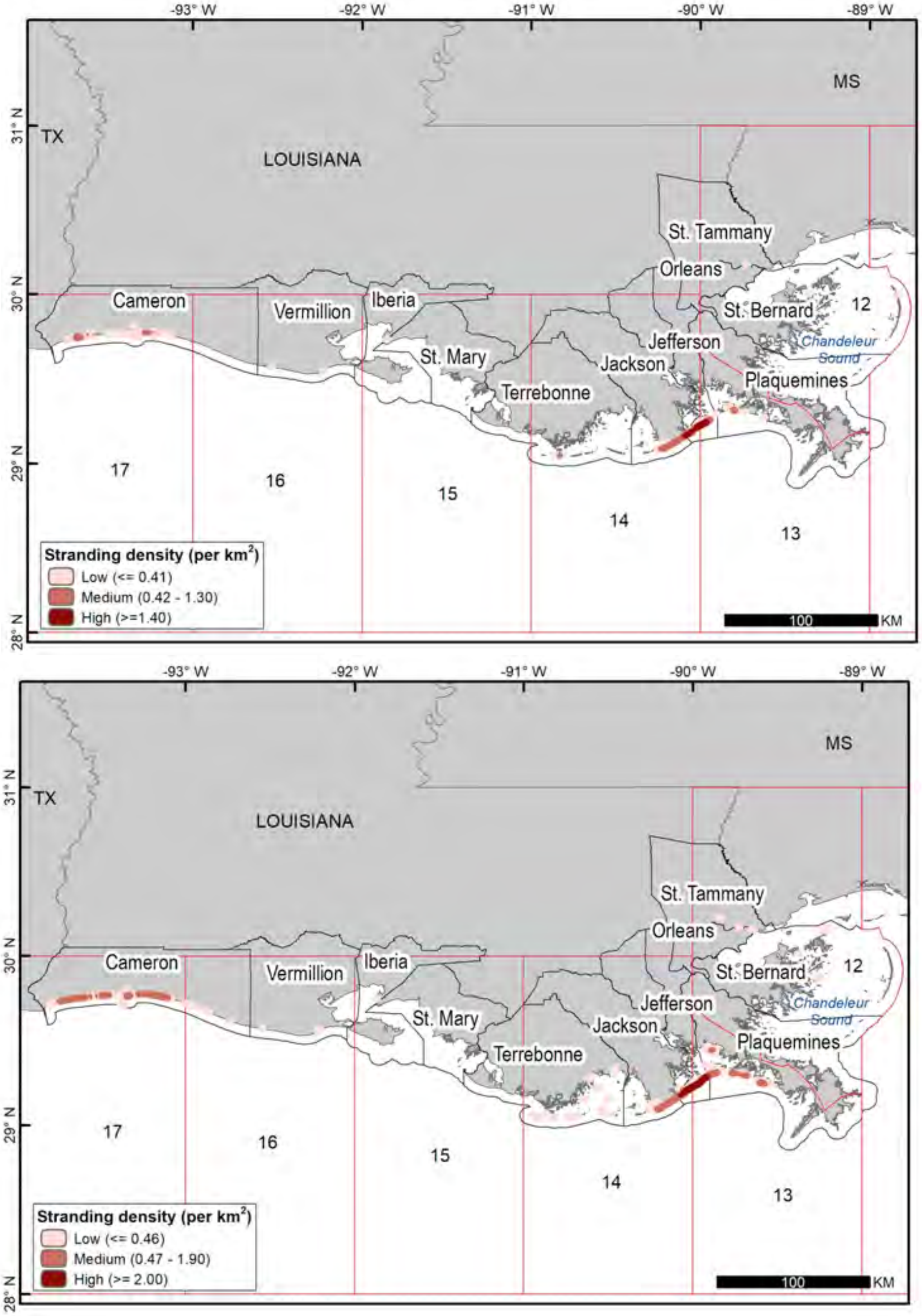


Figure 3-19. Densities of sea turtle strandings documented by the Louisiana STSSN during 2010–2014 (upper image) and 2015–2019 (lower image). High densities of sea turtle strandings were observed in Jefferson Parish along the Grand Isle shoreline

The vast majority of Kemp's ridleys, loggerheads, and green turtles were found dead (88.8%, 98.2%, and 91.8%, respectively), and most were moderately or severely decomposed (Suppl. Table B-11). Histograms of the SCL of stranded turtles are shown by species in Figure 3-20. Mean SCL for Kemp's ridleys was 47.9 ± 12.75 cm (range: 18.3–66.4 cm, n = 151), 76.8 ± 9.34 cm (58.0–95.0 cm, n = 25) for loggerheads, and 34.9 ± 13.8 cm (mean ± one standard deviation [SD], range: 15.6–80.6 cm, n = 31),) for green turtles. Only one dead leatherback turtle and no hawksbills were documented as traditional strandings during 2015–2019.

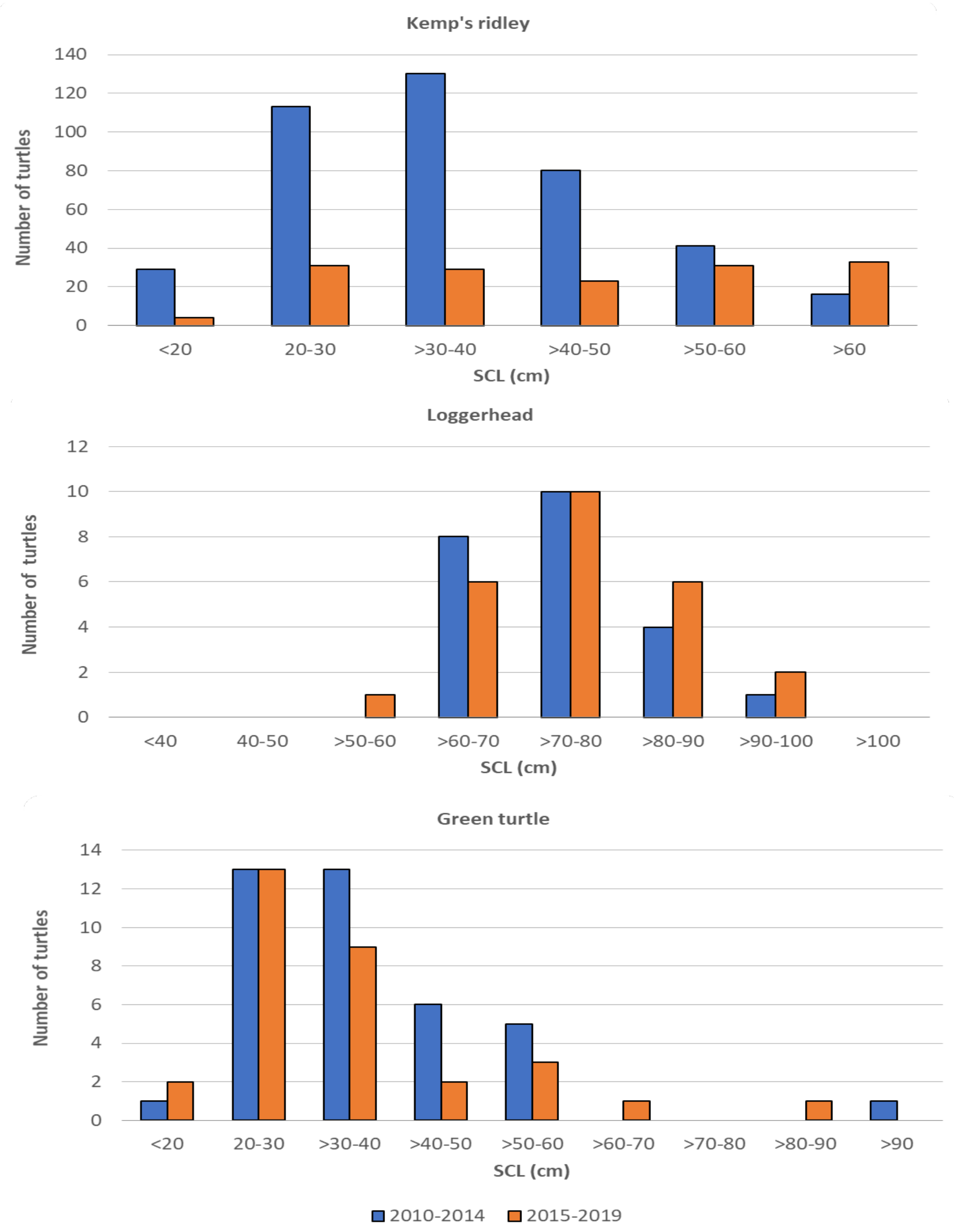


Figure 3-20. Histograms (by species) of straight carapace lengths (SCL) for sea turtles found stranded in Louisiana during 2010–2014 and 2015–2019 (SCL, measured from nuchal notch to caudal tip of the carapace).

Stranding and necropsy findings

Necropsy was performed on 48.1% (163/339) of stranded turtles that were found dead in Louisiana or that were alive and later died (Suppl. Table B-10). Examination findings related to sediment within the respiratory system and GI contents are provided in Suppl. Tables B-12 and B-13, respectively, and are further considered with concurrent findings in the next sections.

Table 3-17. Necropsy findings of stranded sea turtles from Louisiana by species and 5-year period.

Species	No abnormalities	Major injuries	Disease-related	Oiled	Unclassified	Total
Kemp's ridley						
2010–2014	290 (42.7%)	150 (22.1%)	21 (3.1%)	8 (1.2%)	210 (30.9%)	679*
2015–2019	104 (46.8%)	27 (12.2%)	2 (0.9%)	0 (0%)	89 (40.1%)	222
Total	394 (43.7%)	177 (19.6%)	23 (2.6%)	8 (0.9%)	299 (33.2%)	901
Loggerhead						
2010–2014	12 (23.5%)	10 (19.6%)	6 (11.8%)	0 (0%)	23 (45.1%)	51
2015–2019	13 (35.1%)	6 (16.2%)	3 (8.1%)	0 (0%)	15 (40.5%)	37
Total	25 (28.4%)	16 (18.2%)	9 (10.2%)	0 (0%)	38 (43.2%	88
Green						
2010–2014	7 (11.3%)	30 (48.4%)	3 (4.8%)	1 (1.6%)	22 (35.5%)	62
2015–2019	9 (16.7%)	23 (42.6%)	6 (11.1%)	0 (0%)	16 (29.6%)	54
Total	16 (13.8%)	53 (45.7%)	9 (7.8%)	1 (0.9%)	38 (32.8%)	116
Leatherback						
2010–2014	2 (-)	1 (-)	0 (-)	0 (-)	0 (-)	3
2015–2019	1 (-)	0 (-)	0 (-)	0 (-)	0 (-)	1
Total	3 (-)	1 (-)	0 (-)	0 (-)	0 (-)	4
Hawksbill						
2010–2014	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
2015–2019	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
Total	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
Undetermined						
2010–2014	0 (0%)	0 (0%)	0 (0%)	0 (0%)	42 (100%)	42
2015–2019	0 (0%)	0 (0%)	0 (0%)	0 (0%)	25 (100%)	25
Total	0 (0%)	0 (0%)	0 (0%)	0 (0%)	67 (100%)	67
All species						
2010–2014	311 (37.2%)	191 (22.8%)	30 (3.6%)	9 (1.1%)	297 (35.5%)	837
2015–2019	127 (37.5%)	56 (16.5%)	11 (3.2%)	0 (0%)	145 (42.8%)	339
Total	438 (37.2%)	247 (21.0%)	41 (3.5%)	9 (0.8%)	442 (37.6%)	1,176

*Does not include single cold-stunned Kemp's ridley.

Findings categories

Over half (57.2%; 194/339) of strandings in Louisiana could be assigned a findings category. Those that could not be categorized included around 40% of Kemp's ridleys and loggerheads and almost 30% of green turtles. The greater proportion of uncategorized strandings in Louisiana compared to other NGOM states was due to advanced decomposition and fewer photographs available for evaluation. Categories of stranding and necropsy observations are presented by species in Table 3-17 and are shown graphically by the week in Suppl. Figure C-7.

No anomalies. The most frequent finding (46.8%, 104/222) among stranded Kemp's ridleys during 2015–2019 was the absence of apparent abnormalities. The majority of these cases were moderately (45.2%; 47/104) or severely (47.1%; 49/104) decomposed. The greatest number of Kemp's ridleys without anomalies stranded in the spring months (77.9%; 81/104). Many necropsied Kemp's ridleys with no abnormalities (31.9%, 23/72) had sediment within the respiratory tract (either within the trachea/bronchi and/or lungs) (Suppl. Table B-12), and the GI contents included fish in 52 cases (75.4%, 52/69) (Suppl. Table B-13). Of the loggerheads that could be categorized, the most frequent finding (35.1%, 13/37) was no abnormalities. The majority of these cases were moderately (38.5%; 5/13) or severely (38.5%; 5/13) decomposed. Four of these loggerheads had sediment within the respiratory tract (either within the trachea/bronchi and/or lungs), and the GI contents included fish in 4 cases. Nine green turtles stranded with no abnormalities (16.6%), and most of them were moderately decomposed (6/9). All five green turtles necropsied in this category contained food in the upper GI tract.

Trauma. Major injuries were the second-most frequent finding among stranded Kemp's ridleys and loggerheads and included around 20% of strandings of these species (Table 3-18). Trauma was the most frequently assigned category for green turtles, comprising 42.5% (23/54) of green turtle strandings in Louisiana. Vessel strikes were the most common type of trauma for all sea turtle species in Louisiana and included 69.6% (39/56) of observed injuries.

Disease-related. Two Kemp's ridleys had indications of poor health, including emaciation and accumulated epibiota. Three loggerheads also had indications of poor health, including various degrees of weight loss, accumulation of epibiota and/or leech infestation. In one case, the projections of a plastron bone had avulsed due to catabolism of connective tissues (due to emaciation) and perforated the left aorta. Six green turtles were in diminished nutritional condition and/or had evidence of reduced feeding. One of these turtles had a congenital malformation of the tail and vent that led to death from obstruction of the bowel and severe secondary infection.

Table 3-18. Types of injuries observed in sea turtles found stranded in Louisiana by species and 5-year period. Fishing tackle/gear includes hooking injuries, entanglements, and internal injuries from ingestion. Multiple injury types comprise turtles with shark bites in addition to vessel strike wounds or fishery interactions.

Species	Vessel strike	Fishing tackle/gear	Non-fisheries entangle / entrap	Shark bites	Multiple types	Other	Total
Kemp's ridley							
2010–2014	103 (68.7%)	4 (2.7%)	0 (0%)	28 (18.7%)	12 (8.0%)	3 (2.0%)	150
2015–2019	18 (66.7%)	0 (0%)	0 (0%)	7 (25.9%)	0 (0%)	2 (7.4%)	27
Total	121 (68.4%)	4 (2.3%)	0 (0%)	35 (19.8%)	12 (6.8%)	5 (2.8%)	177
Loggerhead							
2010–2014	3 (30.0%)	1 (10.0%)	0 (0%)	5 (50.0%)	0 (0%)	1 (10.0%)	10
2015–2019	3 (-)	1 (-)	0 (-)	0 (-)	0 (-)	2 (-)	6
Total	6 (37.5%)	2 (12.5%)	0 (0%)	5 (31.3%)	0 (0%)	3 (18.8%)	16
Green turtle							
2010–2014	23 (76.7%)	0 (0%)	0 (0%)	4 (13.3%)	3 (10.0%)	0 (0%)	30
2015–2019	18 (78.3%)	2 (8.7%)	1 (4.3%)	1 (4.3%)	0 (0%)	1 (4.3%)	23
Total	41 (77.4%)	2 (3.8%)	1 (1.9%)	5 (9.4%)	3 (5.7%)	1 (1.9%)	53
Leatherback							
2010–2014	1 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	1
2015–2019	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
Total	1 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	1
Hawksbill							
2010–2014	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
2015–2019	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
Total	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
All species							
2010–2014	130 (68.1%)	5 (2.6%)	0 (0%)	37 (19.4%)	15 (7.9%)	4 (2.1%)	191
2015–2019	39 (69.6%)	3 (5.4%)	1 (1.8%)	8 (14.3%)	0 (0%)	5 (8.9%)	56
Total	169 (68.4%)	8 (3.2%)	1 (0.4%)	45 (18.2%)	15 (6.1%)	9 (3.6%)	247

3.5 Environmental analysis

Beaching Probability Index

During 2017–2019, both BPI and strandings increased in Alabama in late February or early March. The initial peak in strandings did not correspond to or immediately follow a period of increased BPI during all years. However, both BPI and strandings tended to be at their highest rates during late spring and summer (Fig. 3-21).

In Mississippi, BPI increased in late February along the coast in 2017 and 2019. During 2018, BPI was elevated during February, but the greatest increase occurred later, during late March. The initial increase in strandings tended to occur during early April (Fig. 3-22).

For the Louisiana coast, the timing of initial BPI increases in the springs of 2017–2019 varied from late February to early April, while strandings tended to increase during early April. Both strandings and BPI tended to be at their highest rates from late spring through early summer (Fig. 3-24).

We evaluated correlations between weekly mean BPI values and the sum of sea turtle strandings recorded for corresponding weeks for three years (2017–2019) and each state and region of interest (Table 3-19).

2017

We observed a slight positive correlation between BPI and strandings recorded along the Mississippi and Alabama coasts during 2017 ($\tau = 0.33$); BPI also had a significant positive effect on strandings. The relationship between the two was nonlinear (Fig. 3-24), but the inclusion of BPI as a quadratic term did not improve model fit. Within the central Louisiana area of interest, a slight positive correlation between BPI and strandings was observed ($\tau = 0.24$). BPI had no significant effect on strandings within central Louisiana. We observed a slight positive correlation between BPI and sea turtle strandings ($\tau = 0.37$). BPI had a significant positive effect on western Louisiana strandings. The relationship between the two was nonlinear (Fig. 3-24), but the inclusion of BPI as a quadratic term did not improve model fit. When we evaluated the data state-by-state, we observed a significant positive correlation between BPI and strandings for all states during 2017 (Table 3-19). The GLM suggested BPI had a significant positive effect on sea turtle strandings within Louisiana and Mississippi (Fig. 3-24).

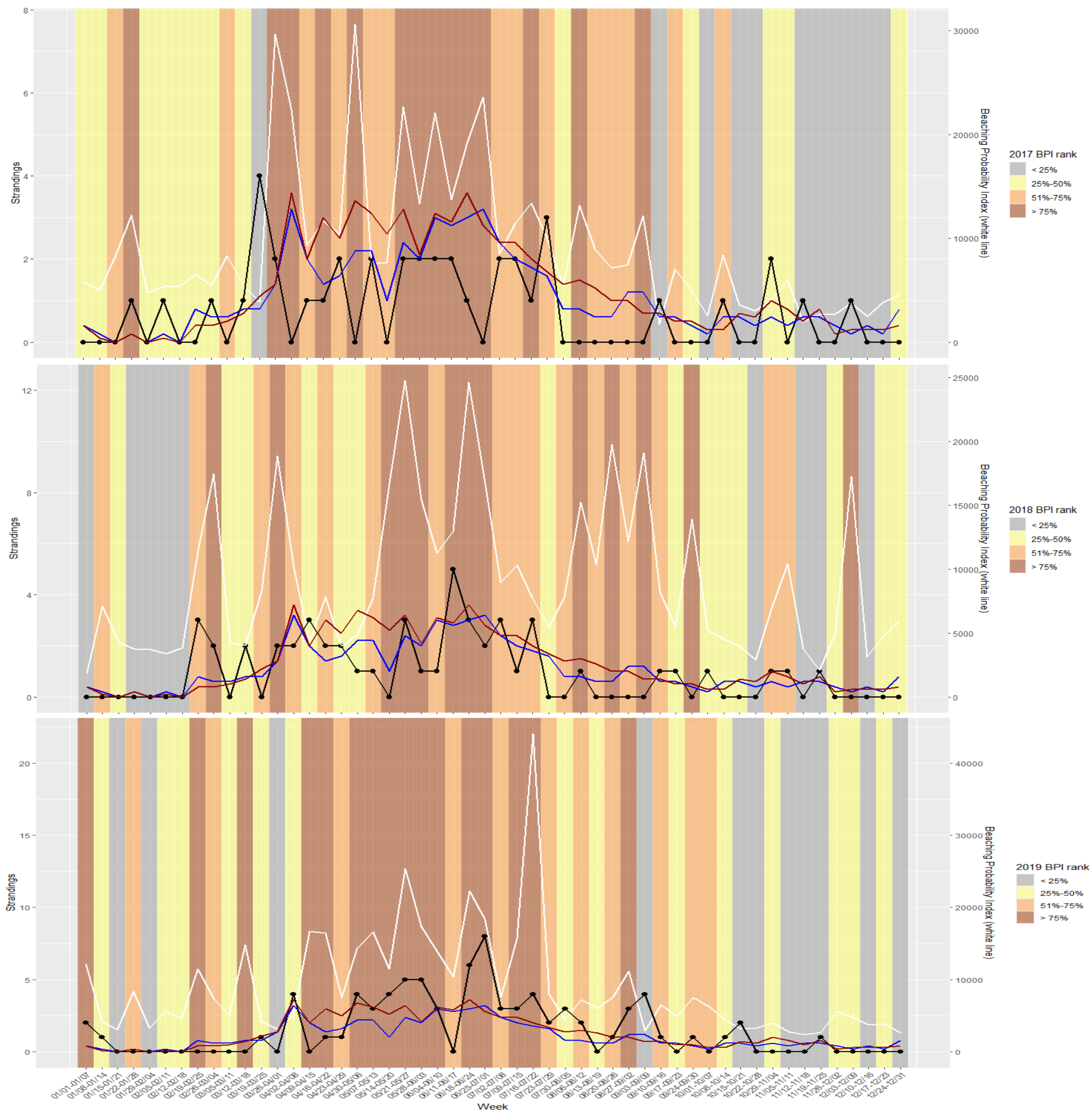


Figure 3-21. Weekly total numbers of all sea turtle strandings in Alabama by year (black line). Weekly average stranding counts for the previous 5 and 10 years are also provided (blue and red lines, respectively). Beaching probability index (white line) is provided as quartiles (background shading). Shown are 2017(top), 2018(middle), and 2019(bottom).

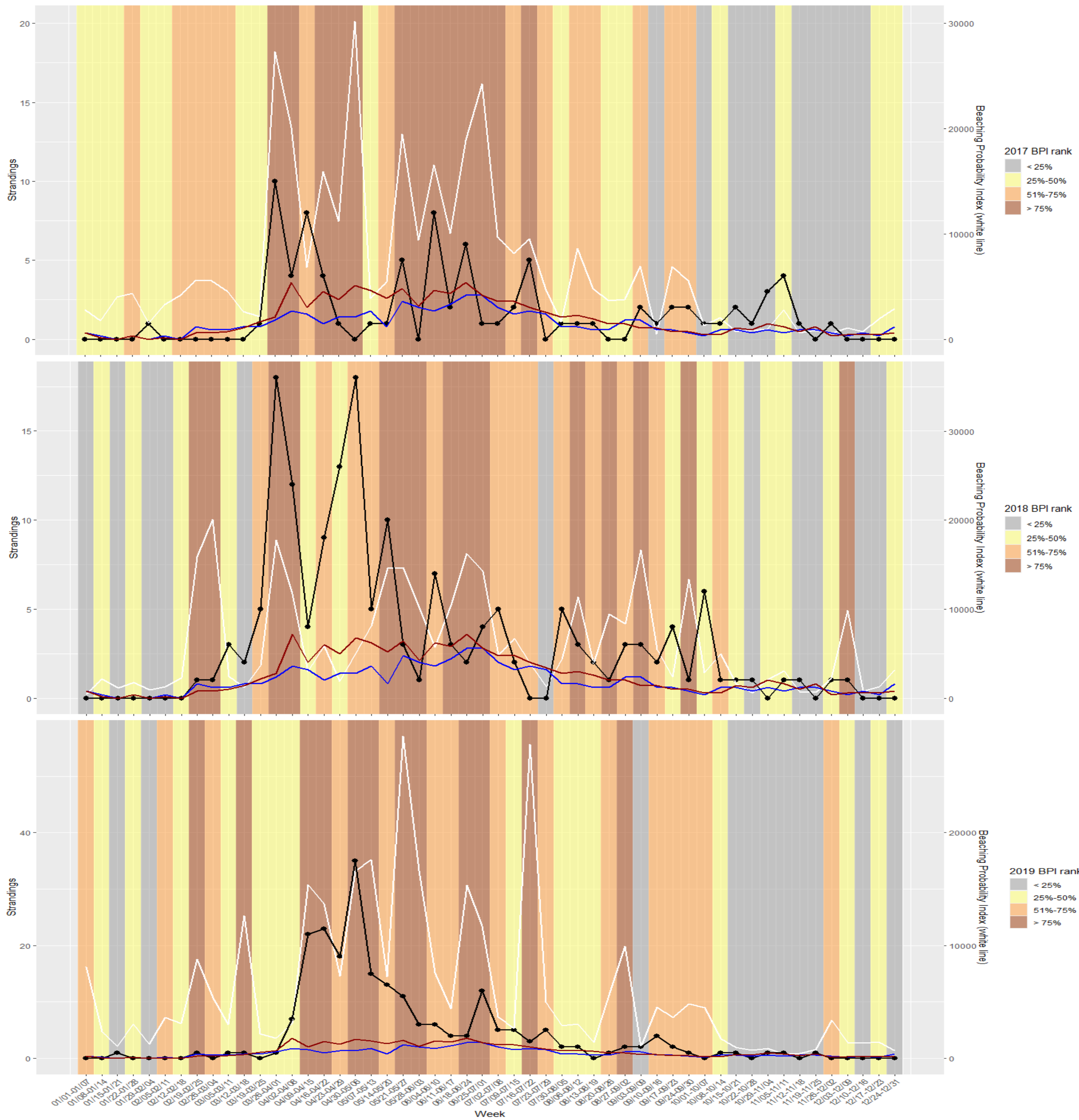


Figure 3-22. Weekly total numbers of all sea turtle strandings in Mississippi by year (black line). Weekly average stranding counts for the previous 5 and 10 years are also provided (blue and red lines, respectively). Beaching probability index (white line) is provided as quartiles (background shading). Shown are 2017(top), 2018(middle), and 2019(bottom).

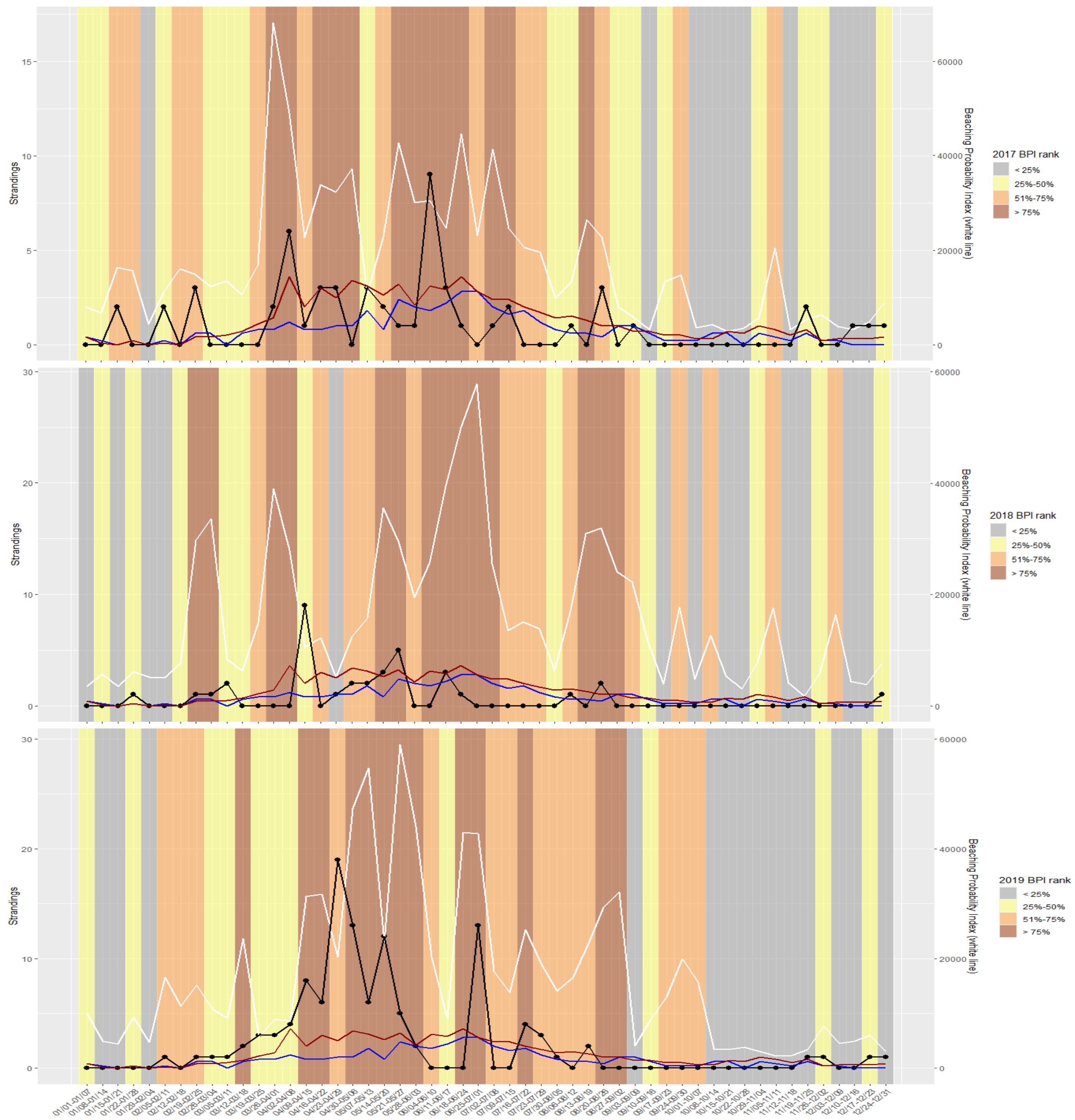


Figure 3-23. Weekly total numbers of all sea turtle strandings in Louisiana by year (black line). Weekly average stranding counts for the previous 5 and 10 years are also provided (blue and red lines, respectively). Beaching probability index (white line) is provided as quartiles (background shading). Shown are 2017(top), 2018(middle), and 2019(bottom).

Table 3-19. Correlations between strandings and BPI during 2017–2019 for each state and three regions of interest: Mississippi–Alabama (A), central Louisiana (B), and western Louisiana (C). Letter labels correspond to those in Fig. 2.3. For each year, Kendall's rank correlation results are provided (τ) and the corresponding value.

Location	2017	2018	2019
MS–AL (A)	τ=0.33, P<0.05	τ=0.37, P<0.05	τ=0.47, P<0.05
Central LA (B)	τ=0.24, P<0.05	τ=0.21, P=0.06	τ=0.42, P<0.05
Western LA (C)	τ=0.37, P<0.05	τ=0.20, P=0.07	τ=0.21, P=0.05
Alabama	τ=0.23, P<0.05	τ=0.28, P<0.05	τ=0.41, P<0.05
Mississippi	τ=0.27, P<0.05	τ=0.37, P<0.05	τ=0.45, P<0.05
Louisiana	τ=0.36, P<0.05	τ=0.27, P<0.05	τ=0.37, P<0.05

2018

We observed a slight positive correlation between BPI and sea turtle strandings recorded along the Mississippi and Alabama coastlines (τ = 0.37); BPI also had a significant positive effect on strandings (Fig. 3-25). We observed no significant correlation between BPI and sea turtle strandings recorded along the central or western Louisiana coastal areas of interest in 2018 (τ = 0.20, P = 0.07; τ = 0.21, P = 0.06). BPI also did not affect strandings within these two areas during 2018. When we evaluated the data state-by-state, we observed a significant positive correlation between BPI and strandings for all states during 2018 (Table 3-19). The GLM suggested BPI had a significant positive effect on sea turtle strandings within Mississippi and Alabama (Fig. 3-25).

2019

Within the Mississippi and Alabama coastlines, BPI was positively correlated with 2019 stranding records (τ = 0.47). The GLM also suggested BPI had a significant positive correlation with strandings within the region (Fig. 3-26). We observed a significant positive correlation between BPI and sea turtle strandings (τ = 0.42) along the central Louisiana coast. The GLM also suggested BPI had a significant positive correlation with strandings reported within central Louisiana during 2019 (Fig. 3-26). We found no significant correlation between BPI and sea turtle strandings recorded along the western Louisiana coast (τ = 0.21, P = 0.05); nor was a significant effect of BPI on strandings identified within the region's GLM. The state-by-state BPI and stranding correlations for 2019 were significant and positive for all three states (Table 3-19). The GLM also suggested BPI had a significant positive correlation with 2019 sea turtle strandings within Louisiana, Mississippi, and Alabama (Fig. 3-26).

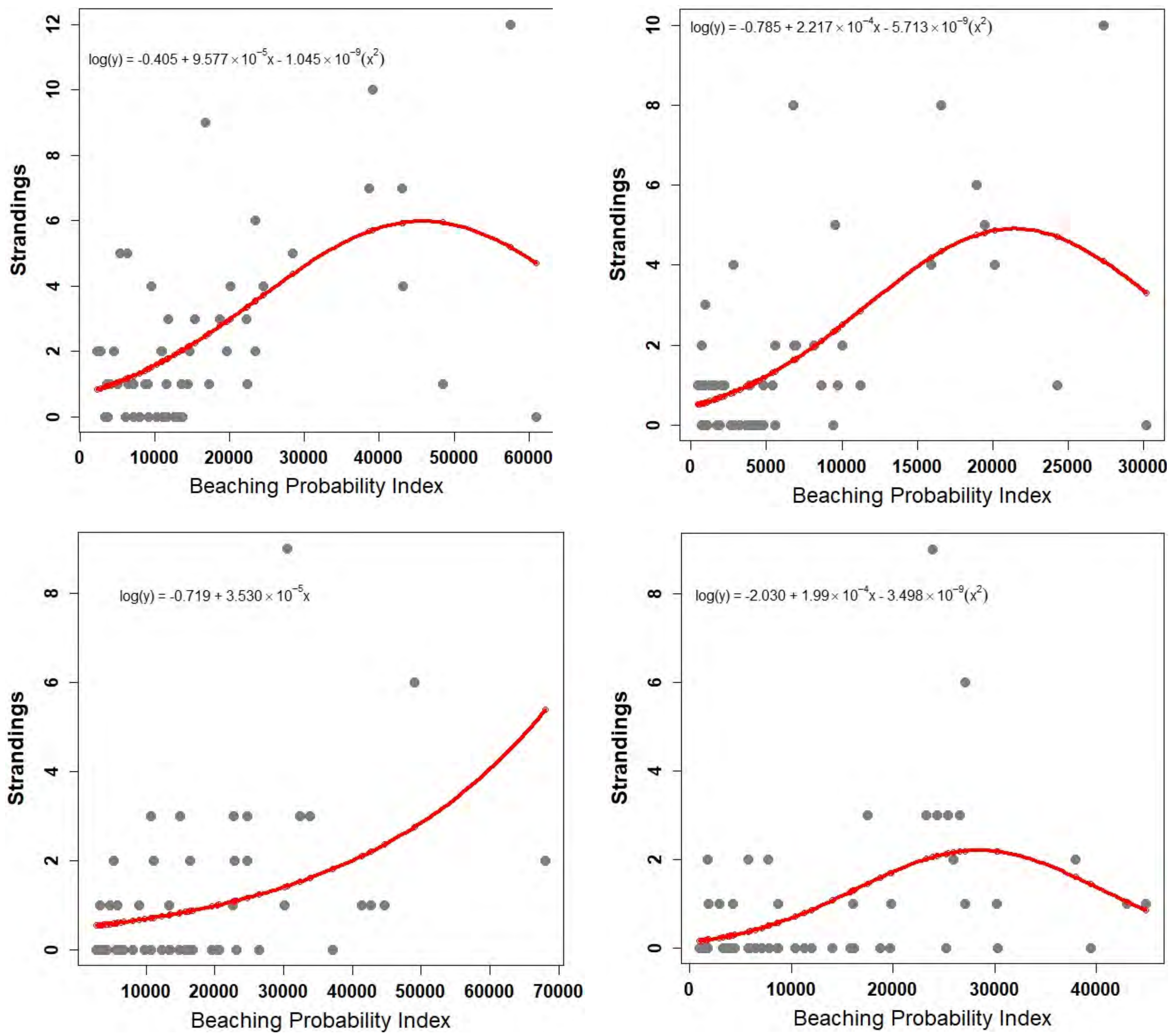
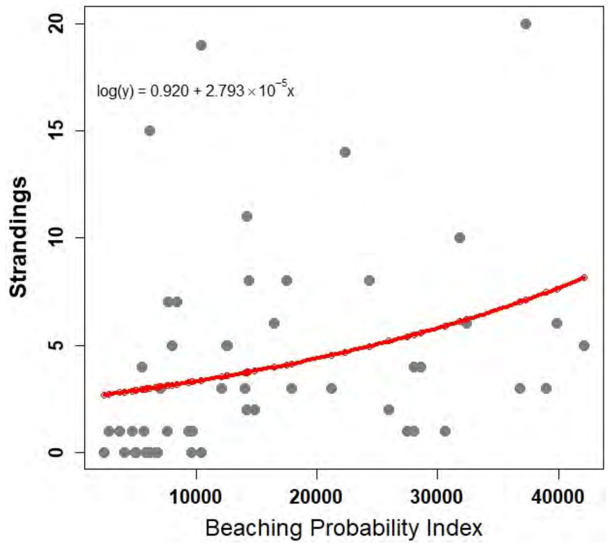
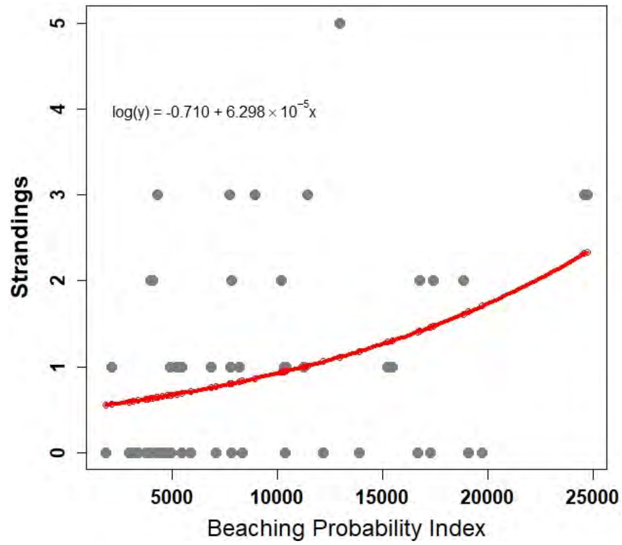


Figure 3-24. Weekly counts of sea turtle strandings recorded during 2017 and the weekly average Beaching Probability Index (BPI) for those in areas of the northern Gulf of Mexico in which the relationship was significant. The red lines represent a quasi-Poisson generalized linear model fit to the data describing the relationship between strandings and BPI. Shown are Alabama and Mississippi coasts combined (upper left); Mississippi coast (upper right); Louisiana coast (lower left); and western Louisiana coast (lower right).





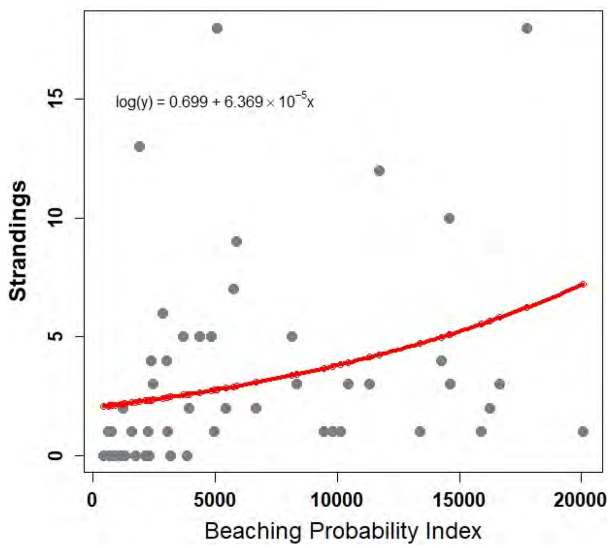
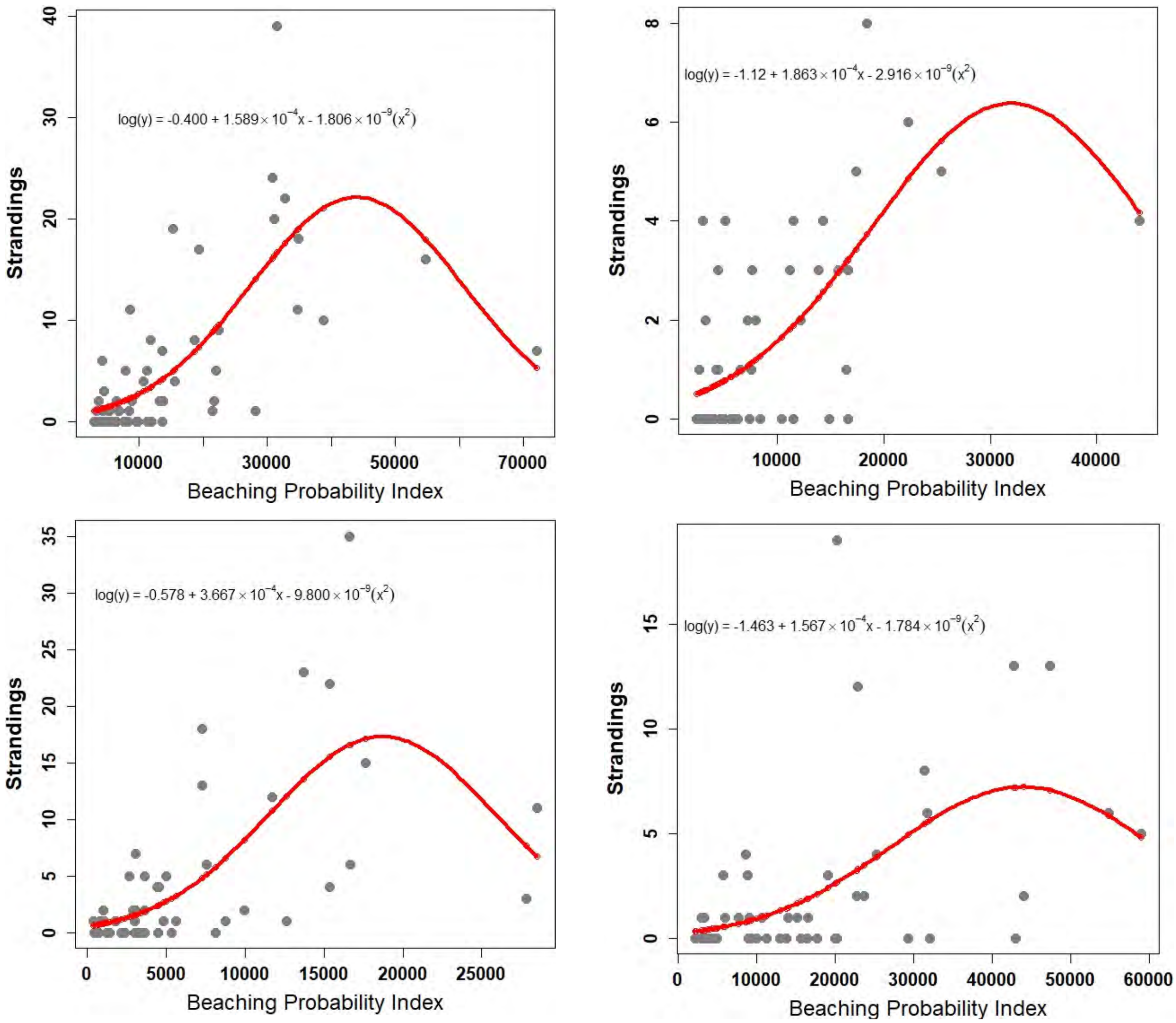


Figure 3-25. Weekly counts of sea turtle strandings recorded during 2018 and the weekly average Beaching Probability Index (BPI) for those in areas of the northern Gulf of Mexico in which the relationship was significant. The red lines represent a quasi-Poisson generalized linear model fit to the data describing the relationship between strandings and BPI. Shown are Alabama and Mississippi coasts combined (upper left); Alabama coast (upper right); Mississippi coast (lower left).



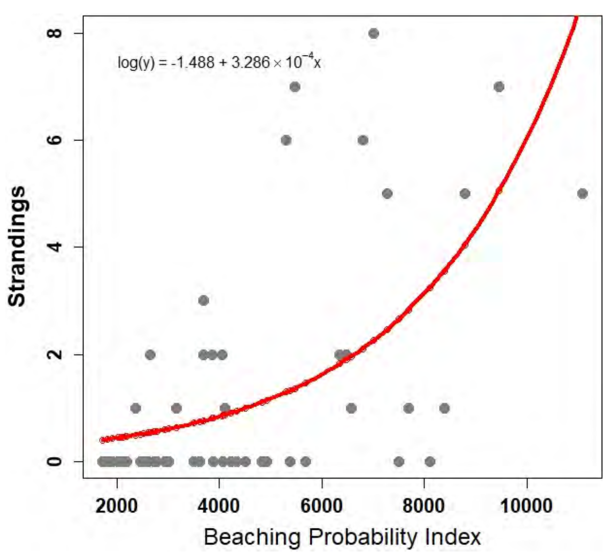


Figure 3-26. Weekly counts of sea turtle strandings recorded during 2019 and the weekly average Beaching Probability Index (BPI) for those in areas of the northern Gulf of Mexico in which the relationship was significant. The red lines represent a quasi-Poisson generalized linear model fit to the data describing the relationship between strandings and BPI. Shown are Alabama and Mississippi coasts combined (upper left); Alabama coast (upper right); Mississippi coast (middle left); Louisiana coast (middle right); central Louisiana coast (lower left).

Buoy observations

Water temperature

During 2010–2019, water temperatures in western Louisiana, at Calcasieu Pass, ranged from 12.2°C (±2.7°C, January mean ± std. dev.) to 30.5°C (±1.4°C, August mean ± std. dev.). Mean daily western Louisiana water temperatures fell below 10°C throughout six winters (2010, 2011, 2014, 2015, 2017, and 2018; Fig. 3-27).

Water temperatures along the central Louisiana coast, at Grand Isle, ranged from 14.6°C (±2.8°C, January mean ± std. dev.) to 30.5°C (±1.3°C, August mean ± std. dev.) during 2010–2019. Mean daily central Louisiana water temperatures fell below 10°C throughout three winters (Dec. 2010–Jan. 2011, 2014, and 2018; Fig. 3-27). Coastal water temperatures along the Mississippi and Alabama coasts ranged from 12.2°C (±2.8°C, January mean ± std. dev.) to 29.9°C (±1.4°C, August mean ± std. dev.) during 2010–2019. Water temperatures in the region fell below 10°C for extended periods during four winters (2011, 2014, 2015, and 2018; Fig. 3-27). Cold-stunned turtles are rarely encountered in these three states despite brief periods where water temperatures plausibly could result in the phenomena if turtles were present.

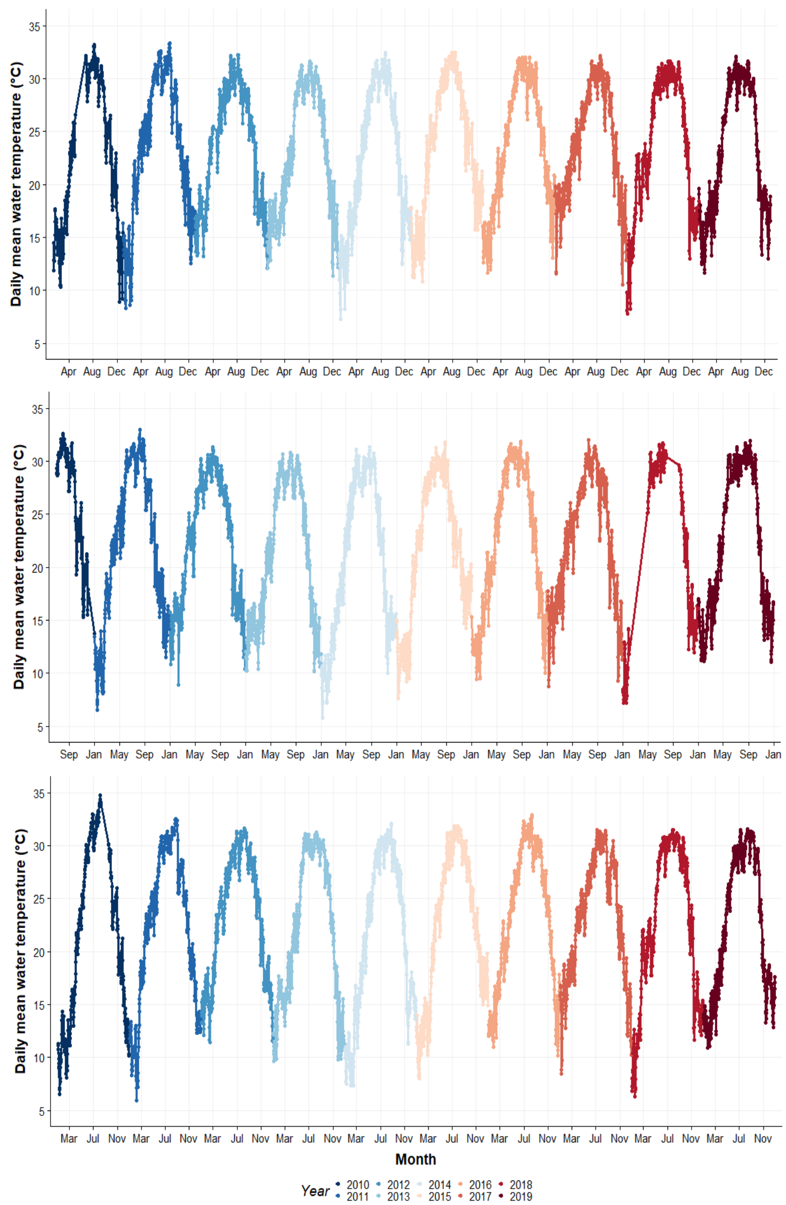


Figure 3-27. Mean daily water temperature values during 2010–2019 observed at three NOAA National Data Buoy Center stations : obtained from the NDBC Dauphin Island station (DPHA1) in Alabama (top); NDBC Grand Isle station (GIPL1) in central Louisiana (middle); and NDBC Calcasieu Pass station (CAPL1) in western Louisiana (bottom).

Wind direction and velocity

We obtained wind velocity data recorded during 2010–2019 by the three NDBC stations representative of the three northern Gulf of Mexico regions to corroborate BPI predictions

(Fig. 2-3). We summarized wind velocity data within four seasons: winter (December–February), spring (March–May), summer (June–August), and fall (September–November), which roughly encompass distinct periods of sea turtle strandings (Table 3-20). Mean wind velocity tended to be higher in the winter and spring months than during the summer and fall months. We also summarized 2010–2019 wind velocity by week, creating a 10-year summary against which individual weekly means could be compared to identify periods of relatively high wind speeds (Fig. 3-28).

Table 3-20. Wind speeds (mean ± std. dev. km hr^{-1}) observed at three NOAA National Data Buoy Center stations selected from three locations representing northern Gulf of Mexico coastal waters. Data from 2010–2019 were summarized within four seasons: winter (December–February), spring (March-May), summer (June–August), and fall (September–November). Data were obtained from the following NDBC stations: Dauphin Island, AL (A), Grand Isle, LA (B), Calcasieu Pass, LA (C); letter labels correspond to those in Fig. 2.3.

Location	Winter	Spring	Summer	Fall
MS–AL (A)	20.5±10.9 km hr^{-1}	19.5±10.0 km hr^{-1}	15.0±8.1 km hr^{-1}	19.1±10.6 km hr^{-1}
Central LA (B)	15.8±8.9 km hr^{-1}	14.3±7.4 km hr^{-1}	11.4±6.3 km hr^{-1}	13.9±7.7 km hr^{-1}
Western LA (C)	18.0±8.1 km hr^{-1}	20.1±8.8 km hr^{-1}	17.4±7.8 km hr^{-1}	16.7±7.7 km hr^{-1}

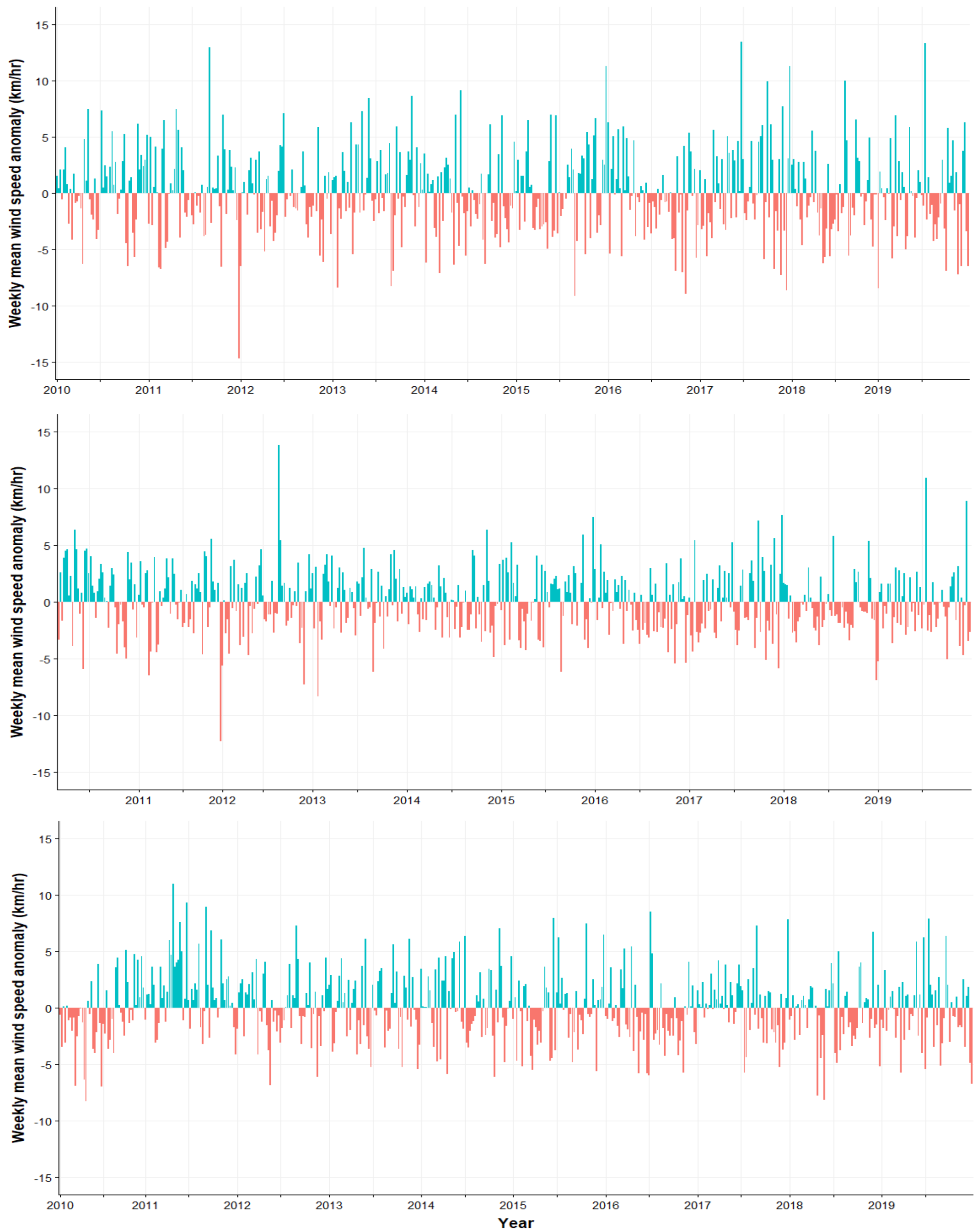


Figure 3-28. Mean weekly wind velocity by values during 2010–2019 observed at three NOAA National Data Buoy Center stations: obtained from the NDBC Dauphin Island station (DPHA1) in Alabama (top); NDBC Grand Isle station (GIPL1) in central Louisiana (middle); and NDBC Calcasieu Pass station (CAPL1) in western Louisiana (bottom).

Freshwater diversions

Over the 90 years since its construction, the BCS has opened 15 times, five of which occurred throughout 2010–2019 (USACE 2021). During the spillway operation, suspended materials in the water from the Mississippi River are deposited in the floodway and Lake Pontchartrain and Lake Borgne, which empty into the western Mississippi Sound. The addition of freshwater into these brackish and saline areas typically only has an immediate, short-term environmental effect. The duration of the opening, number of bays open, and volume of water released varied considerably for the last five BCS openings (Table 3-21). During 2016 and 2018, the spillway was opened for ≤30 days; 5.6 million and 4.7 million acre-feet of water were discharged, respectively. The 2016 opening occurred in January, and 1.4% (2/140) of Mississippi sea turtle strandings were documented in this open period, and zero were reported in February. Following the typical seasonal pattern in this region, strandings in 2016 were highest in March and April (54.3%; 76/140), and 83% (116/140) occurred from March through July. The 2018 opening occurred in March and coincided with 21% (27/126) of reported strandings; 76.2% (96/126) were reported in March through May. The 2011 opening occurred in May and June, lasted 42 days, and discharged 17.4 million acre-feet of water. Prior to this opening, 64.4% (188) of the 292 documented sea turtle strandings in 2011 had already occurred; 2011 had the second-highest number of strandings during the 10 years. An additional 25 (8.6%) sea turtle strandings were reported in the three months after the opening. In 2019, the spillway was opened two times (Feb 27–Apr 12 and May 10–Jul 27) for a total of 123 days, nearly twice as long as any previous yearly opening, releasing a total of 30.9 million acre-feet of freshwater into Lake(s) Pontchartrain and Borgne, and the Mississippi Sound. The freshwater discharge was nearly twice that of the 2011 opening. The majority (92.0%) of strandings (184/200) in 2019 were documented while the BCS was open; however, this period coincided with the typical peak sea turtle stranding season in Mississippi based on 5 and 10-yr historical averages. Salinity data indicated that the Western Mississippi Sound salinities were extremely low (0–10 ppt) from mid-March into July 2019 (USGS, 2021). Hurricane Barry made landfall in Louisiana on July 13, 2019, and salinities temporarily increased (>25 ppt), and by early August, salinities were >10 ppt (USGS, 2021).

The Mississippi STSSN documented ≥200 strandings per year in 2010 (318), 2011 (292), 2013 (224), and 2019 (200). From 2010–2019, 80.7% (1,425/1,765) of strandings occurred during March through June, ranging from 67% to 87% annually (Table 3-22). The opening of the BCS typically occurs in the spring, and as a result, overlapped with peak sea turtle stranding months (March–June) in three of the four years it was open. The second and fourth highest stranding years (2011 and 2019, respectively) coincided with the BCS opening. During the four years that the BCS was open, 758 strandings were documented, and during the six years that the BCS did not open, 1,007 strandings were documented.

Table 3-21. Operation of Bonnet Carré Spillway from 2015–2019. Weeks opened are the calendar weeks the spillway was open.

Year	Opening Date	Days Opened	Weeks Opened	Bays Opened	Estimated Total Discharge (acre-feet)
2011	May 9	42	19-24	330	17,742,653
2016	January 10	22	2-4	210	5,600,435
2018	March 8	30	10-14	186	4,676,996
2019 (First)	February 27	44	9-15	206	12,226,042
2019 (Second)	May 10	79	20-30	168	18,670,301

Table 3-22. Overall percentage of sea turtle strandings in Mississippi from 2010–2019. Peak stranding months, containing 75%+ of strandings, are highlighted in blue. Years that the Bonnet Carre Spillway was opened are indicated by asterisks and stranding numbers for those months of the opening are in bold.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2010	0%	0%	0%	3%	28%	41%	8%	6%	5%	5%	3%	1%	100%
2011*	1%	0%	16%	47%	12%	13%	6%	1%	2%	1%	2%	0%	100%
2012	2%	0%	36%	30%	12%	9%	5%	0%	2%	2%	1%	0%	100%
2013	0%	0%	1%	42%	29%	13%	5%	2%	2%	4%	0%	0%	100%
2014	0%	1%	1%	35%	35%	11%	2%	3%	3%	9%	0%	1%	100%
2015	0%	0%	1%	35%	14%	16%	3%	7%	4%	10%	4%	4%	100%
2016*	1%	0%	23%	31%	7%	12%	9%	2%	6%	4%	3%	1%	100%
2017	0%	2%	14%	26%	11%	21%	11%	2%	2%	3%	9%	2%	100%
2018*	0%	1%	21%	32%	23%	7%	2%	4%	4%	3%	2%	2%	100%
2019*	1%	1%	2%	36%	37%	11%	7%	3%	2%	1%	2%	0%	100%
Total	1%	0%	10%	31%	23%	17%	6%	3%	3%	4%	2%	1%	100%

Harmful algal blooms

Two types of harmful algal blooms were documented in the NGOM during 2015–2019 that merit consideration concerning possible health implications for sea turtles. The first was a *Karenia brevis* bloom (red tide) in 2015 and 2016. The second was episodic cyanobacterium (blue-green algae) blooms, the most extensive of which occurred in 2019. Results of all biotoxin analyses are provided in Suppl. Table B-14.

A *K. brevis* bloom began in waters off the Florida panhandle during September 2015, leading to fish kills and human respiratory irritation reports beginning around October. The bloom expanded into Alabama waters in November and was in the Mississippi Sound by December. Fish kills were reported in Hancock County, Mississippi, in December 2015. The bloom dissipated in late December and January when *K. brevis* concentrations returned to background levels. Stranded sea turtles with relatively high brevetoxin concentrations (1,000s ng/g in digestive contents) were found on the western Florida panhandle during this bloom through January 2016, and strandings were above the 5 and 10-yr historical averages in Bay and Gulf counties for 2015 (Florida Fish and Wildlife Conservation Commission data). Very few strandings were documented in the NGOM, as is typical for this period; thus, relatively few turtles were available for testing outside of Florida.

We opportunistically analyzed samples from loggerhead and Kemp's ridley turtles stranded in Alabama and Mississippi, respectively, during October 2015, before the red tide was recorded in the area. Both turtles had relatively low concentrations of brevetoxins similar to those observed in sea turtles without recognized blooms, which are regarded as probable background (i.e., subclinical) exposure (Foley et al., 2017). Only two stranded sea turtles were available from Mississippi and Alabama throughout the actual bloom. Concentrations in a Kemp's ridley found in Harrison County, Mississippi, on 12/1/2015 were less than 100 ng/g. A loggerhead that stranded in Baldwin County, Alabama on 12/28/2015 had a fecal brevetoxin concentration of 4,048 ng/g, indicating relatively high exposure. This turtle was underweight and heavily parasitized; indicating conditions that likely preceded the red tide. We also analyzed samples from 3 Kemp's ridleys from Alabama and 9 Kemp's ridleys, and 1 loggerhead from Mississippi that stranded in March 2016 at the beginning of the usual spring rise in strandings. Brevetoxin concentrations were relatively low, consistent with environmental indications that the bloom had dissipated a few months prior to these strandings. Therefore, we did not find evidence of ongoing brevetoxin exposure at concentrations associated with sea turtle mortality.

Cyanobacterium blooms have occurred in the Mississippi Sound following the release of nutrient-rich water from the BCS opening, leading to human health advisories and numerous beach closures from June to October. We screened 5 Kemp's ridleys that stranded during an intense bloom in June and July 2019 for exposure to microcystins and nodularins, which are the principal toxins associated with cyanobacteria. Low concentrations were detected by ELISA and were too low for confirmation by LC-MS/MS. Thus, any microsystin exposure in these turtles appeared very low during this bloom. Additional testing was not pursued based on these results, the absence of concurrent elevation in sea turtle strandings, and the absence of stranded turtles with abnormal clinical signs or other unique presentations.

3.6 Incidental captures

A total of 1,263 sea turtle incidental captures were documented (Table 3-23) across the NGOM during 2010–2019. The vast majority (95.8% (1,210/1,263) were sea turtles incidentally captured by recreational anglers using hook and line gear followed by various types of trawl gear (2.4%; 29/1,210), other gear types (1.0%; 13/1,263), and commercial dredges (0.9%; 11/1,263). Incidental capture data are presented by species and capture type in Table 3-24. Reports included 1,105 (87.6%) Kemp's ridleys, 26 (2.1%) loggerheads, 11 (0.9%) green turtles, 1 leatherback, and 120 (9.5%) sea turtles that could not be identified to species because they were released before stranding responders arrived. The majority of incidentally captured sea turtles were juvenile Kemp's ridleys (1,038/89.0%). Mean SCL for incidentally captured Kemp's ridley turtles was 30.8 ± 4.2 cm (19.5–63.3 cm, n = 1,006), 42.5 ± 21.4 cm (range: 25.0–81.15 cm, n = 10) for loggerheads, and 35.2 ± 5.8 cm (mean ± one standard deviation [SD], range: 27.4–41.4 cm, n = 8), for green turtles.

Mississippi documented 94.0% (1,187/1,263) of incidental captures from 2010–2019, of which 96.4% (1,167) were sea turtles caught by recreational anglers that were hook and line fishing. Alabama documented 3.3% (42/1,263) incidental captures, most (88.1%; n=37) of which were also recreational hook and line captures. Louisiana incidental captures (2.7%, 34/1,263) included six recreational hook and line interactions. Total region-wide incidental captures during 2015–2019 (n = 388) decreased by 55.7% from the previous 5-year total of 875 incidental captures. The decrease was due to the decline in recreational hook and line captures on Mississippi fishing piers over the ten years.

Table 3-23. Sea turtle incidental captures in the northern Gulf of Mexico by state, capture type, and 5-year period. Proportions of each capture type among states are given in parentheses.

Capture type		AL	MS	LA	Total
Dredge					
	2010–2014	0 (-)	4 (-)	3 (-)	7
	2015–2019	0 (-)	2 (-)	2 (-)	4
	Total	0 (-)	6 (54.5%)	5 (45.5%)	11
Recreational hook & line					
	2010–2014	17 (2.0%)	822 (97.5%)	4 (0.5%)	843
	2015–2019	20 (5.4%)	345 (94.0%)	2 (0.5%)	367
	Total	37 (3.1%)	1,167 (96.4%)	6 (0.5%)	1,210
Trawl*					
	2010–2014	3 (17.6%)	4 (23.5%)	10 (58.8%)	17
	2015–2019	1 (8.3%)	6 (50.0%)	5 (41.7%)	12
	Total	4 (13.8%)	10 (34.5%)	15 (51.7%)	29
Other**					
	2010–2014	1 (-)	3 (-)	4 (-)	8
	2015–2019	0 (-)	1 (-)	4 (-)	5
	Total	1 (7.7%)	4 (30.8%)	8 (61.5%)	13
All captures					
	2010–2014	21 (2.4%)	833 (95.2%)	21 (2.4%)	875
	2015–2019	21 (5.4%)	354 (91.2%)	13 (3.4%)	388
	Total	42 (3.3%)	1,187 (94.0%)	34 (2.7%)	1,263

*Trawl includes otter (6), skimmer (9), relocation (3), and research (11) trawls.
**Other includes gillnet (4), cast net (1), haul seine (1), moon pool (3), and bottom longline (3).

Table 3-24. Sea turtle incidental captures in the northern Gulf of Mexico by species, capture type, and 5-year period. Proportions of each capture type among species are given in parentheses.

Capture type		Kemp's ridley	Loggerhead	Green	Unknown	Total
Dredge						
	2010–2014	5 (-)	2 (-)	0 (-)	0 (-)	7
	2015–2019	3 (-)	1 (-)	0 (-)	0 (-)	4
	Total	8 (72.7%)	3 (27.3%)	0 (0%)	0 (0%)	11
Recreational hook & line						
	2010–2014	746 (88.5%)	9 (1.1%)	3 (0.4%)	85 (10.1%)	843
	2015–2019	326 (88.8%)	4 (1.1%)	5 (1.4%)	32 (8.7%)	367
	Total	1,167 (96.4%)	13 (1.1%)	8 (0.7%)	117 (9.7%)	1,210
Trawl*						
	2010–2014	11 (64.7%)	3 (17.6%)	0 (0%)	3 (17.6%)	17
	2015–2019	8 (66.7%)	4 (33.3%)	0 (0%)	0 (0%)	12
	Total	19 (65.5%)	4 (13.8%)	0 (0%)	3 (10.3%)	29
Other**						
	2010–2014	4 (-)	2 (-)	1 (-)	0 (-)	7
	2015–2019	2 (-)	1 (-)	2 (-)	0 (-)	5
	Total	6 (50.0%)	3 (25.0%)	3 (25.0%)	0 (0%)	12
All captures						
	2010–2014	766 (87.6%)	16 (1.8%)	4 (0.5%)	88 (10.1%)	874
	2015–2019	339 (87.4%)	10 (2.6%)	7 (1.8%)	32 (8.2%)	388
	Total	1,105 (87.6%)	26 (2.1%)	11 (0.9%)	120 (9.5%)	1,262

*Trawl includes otter (6), skimmer (9), relocation (3), and research (11) trawls.
**Other includes gillnet (4), cast net (1), haul seine (1), moon pool (3), and bottom longline (3).
***Does not include a leatherback incidentally captured in a moon pool in 2011.

4. Discussion

Sea turtle strandings and incidental captures: numbers and trends

Prior to the DWH oil spill in 2010, documentation and reporting of sea turtle strandings was inconsistent for much of the NGOM. Stranding surveys conducted in Louisiana in the 1990s reported numbers of stranded sea turtles on par with recent years; however, the historical record is generally inadequate for confident comparison and virtually nonexistent for some areas. The enhancements and organization of the NGOM STSSN and related efforts following the DWH spill have dramatically improved our awareness and understanding of sea turtle strandings in this region. Nonetheless, there are persistent challenges inherent to both the sparse historical record before 2010 and the coastal geography of the NGOM, which includes vast, remote areas and marshlands where stranded sea turtles are unlikely to be found. These blind spots further narrow an already limited perspective of at-sea mortality afforded by the study of stranded sea turtles.

The most dramatic observation over the decade of this report was a notable decline in the numbers of documented stranded Kemp's ridley turtles, which was 58% lower in 2015–2019 than in the previous 5-years. This trend was not observed in neighboring Florida or Texas, where numbers of Kemp's ridley strandings have been gradually increasing or have remained relatively constant, respectively, over the same period (A. Foley, D. Shaver, pers. comm.). The reason(s) for fewer Kemp's ridley strandings in the NGOM is unknown. It may reflect changes in stranding reporting and documentation, sea turtle distribution and abundance, and/or stranding causes.

There were shoreline activities in response to the DWH spill and subsequent Natural Resource Damage Assessment (NRDA) that may have generated more opportunistic reporting of stranded sea turtles during the initial years of this report. Enhanced search effort and reporting rates related to the DWH spill have been demonstrated for dolphin strandings (Pitchford et al., 2018). While a similar spill response effect may have influenced reporting of sea turtle strandings in some areas of the NGOM, it seems that any waning of reports from spill response or NRDA would have been counterbalanced by persistent public outreach from resource agencies and stranding organizations. For example, efforts to document sea turtle strandings on Mississippi barrier islands through surveys and enlistment of new STSSN participants increased reports from islands by about 10%. This increase in reporting from the barrier islands may also explain the documentation of larger sea turtles within the last 5 years.

Furthermore, the Mississippi mainland beaches with the highest reporting, response coverage, and outreach (Harrison County) had the greatest decrease in strandings over time. The trend in this particularly well-monitored area indicates that there was likely an actual decrease in strandings over time along this coastline. Nonetheless, public reporting may be more variable or lower than is generally assumed. A recent carcass drift study found that public reporting of beachcast stranded sea turtles was surprisingly low in MS at around 50% on mainland beaches and only 11% on barrier islands (Cook et al., 2021). In addition, fine-scale changes in the dispersal of strandings could result in turtles landing in non-surveyed areas or marshlands where carcasses are unlikely to be found. However, we did not detect significant differences in stranding locations over time aside from greater reporting from Mississippi barrier islands attributable to a more substantial survey effort.

The concurrent decrease in the numbers of Kemp's ridleys reported caught by recreational hook and line fishing suggests that there may have been a change in sea turtle abundance and distribution within the NGOM throughout this reporting period. Although many fishing piers were damaged in 2017 due to Hurricane Nate, the dramatic drop in incidental captures began in 2016 while all piers were operational. The Institute for Marine Mammal Studies also conducted angler surveys on fishing piers during 2016 to expand surveys conducted in 2013 (Cook et al., 2020). There is no evidence to support a decrease in angler reporting. While the NGOM is recognized as important Kemp's ridley turtle habitat, there have been very limited in-water and telemetry studies of juvenile sea turtles in this region (Coleman et al., 2017). In addition, the sparse historical stranding record does not allow us to examine previous years confidently for similar ebbs and flows in strandings. Sea turtle distribution in the NGOM could be dynamic and influenced by a host of factors, such as changes in habitat and/or prey abundance, including those precipitated by freshwater diversions. Additional studies of Kemp's ridley distribution and movements in the region are needed.

Another consideration for reduced strandings is a possible reduction in Kemp's ridley mortality during the most recent 5-years due to decreased overlap between sea turtles and mortality sources and/or effectiveness of mitigation measures. As presented in the next section, bycatch in commercial fisheries is an ongoing concern in the NGOM as a contributing cause of sea turtle strandings. Attention from the NGOM strandings has generated additional fisheries law enforcement interest and intensified efforts by NOAA's Gear Monitoring Team to promote proper use of Turtle Excluder Devices. The Gear Monitoring Team's capacity and operations were expanded as a critical element of NOAA's DWH Sea Turtle Early Restoration Project. Although available data are insufficient to examine potential relationships between sea turtle strandings and fisheries' effort or potential benefits of enforcement and outreach, fewer strandings with indications of fisheries interaction are the aspired result of mitigation efforts.

We also considered other events that could have affected abundance, including variation in annual Kemp's ridley nesting numbers and estimated mortality attributed to the DWH spill. However, these factors do not align temporally with observed stranding trends and size classes, nor would they explain the lack of similar trends in other states.

Continuation of the NGOM STSSN and efforts to improve detection and reporting of sea turtle strandings are essential to building upon the existing dataset and yielding insight into the trends and observations of the last decade. Advances in the network have improved detection in remote areas through dedicated surveys and enlistment of new STSSN collaborators. Furthermore, we have gained substantial knowledge about the region's drift and dispersal of stranded sea turtles to help guide these efforts (Nero et al., 2013; Cook et al., 2021). The collective investment in stranding response and necropsies should be maintained, as strandings remain one of our few mortality and wildlife health indicators. Moreover, the drivers of strandings are too complex, and our understanding of them is too limited to predict future trends in the NGOM. The decline observed over the last 5 years could quickly reverse in the coming years.

Causes of sea turtle strandings in the NGOM

Based on the categorization approach applied to our review of stranding data, we identified and inferred or suspected the causes of stranding for a substantial proportion (70.9%) of sea turtles documented in the NGOM. The ratio of strandings that could not be categorized is typical for strandings in this region, where most sea turtles are moderately or severely decomposed upon discovery. Those that were not categorized due to postmortem state were more likely to be turtles without evident anomalies or potentially those with health issues because commonly encountered major injuries, such as vessel strikes or trauma inflicted by predators, tend to be apparent even when turtles are severely decomposed, incomplete, or even skeletonized. Moreover, when strandings result from disease states, e.g., infectious disease or biotoxicosis, we tend to find relatively high proportions of turtles in good postmortem condition because many come ashore alive and debilitated (Fauquier et al., 2013; Stacy et al., 2019). Although we acknowledge that nearly 30% of strandings could not be further characterized, we feel that the principal characteristics of sea turtle strandings in this region are well represented by the data presented. We consider each category of stranding and relevant associated information for this reporting period in the following paragraphs.

Strandings without evident abnormalities

As in previous years, most Kemp's ridleys and notable proportions of loggerheads and green turtles (44.1%; 1,594/3,616 – all species) stranded in the NGOM were found dead, did not have any significant injuries or indications of disease, and had evidence of recent feeding (Stacy, 2012; 2015). These collective findings are consistent with a relatively sudden cause of death. A large proportion of these cases also had sediment within the respiratory tract, including within the lungs, suggesting they aspirated sediment-rich drowning medium as they died. The absence of apparent debilitating conditions, injuries, or evidence of ongoing exposure to biotoxins indicates that many of the strandings resulted from the drowning of otherwise healthy sea turtles, as occurs when animals are forcibly prevented from reaching the surface for air (i.e., due to forced submergence or underwater entrapment). Incidental capture in trawls and purse seine nets is the only plausible cause of forced submergence in this region that would affect relatively large numbers of sea turtles, not leave any apparent injuries, and manifest as a consistent, annual occurrence. As presented in previous reports (Stacy, 2012; Stacy and Schroeder, 2016), incidental capture by commercial fisheries remains strongly suspected as the cause of many of these strandings based on the systematic exclusion of other possible explanations. Although total numbers of strandings were lower in the most recent 5-year period, the proportions of strandings suspicious for forced submergence were higher for all three sea turtle species that most commonly strand within the NGOM.

The high frequency of finfish ingestion in Kemp's ridleys and loggerheads also points to possible drowning due to fisheries interaction. Free-swimming fish easily evade sea turtles in most circumstances and thus are not considered frequent natural prey for sea turtles. Observations of finfish in the GI contents of sea turtles are generally attributed to opportunistic foraging on dead fish sources, particularly bycatch (Shaver, 1991; Cannon, 1998). We documented fish ingestion in nearly 80% (749/946) of stranded Kemp's ridleys and over 50% of loggerheads (22/41) without other abnormalities over the ten years of this report, suggesting frequent co-location of stranded turtles with sources of dead fish. Fish ingestion was also a frequent finding (72%) in fecal samples from live Kemp's ridleys from the Mississippi Sound (Pitchford et al., 2016). Moreover, we suspect that bycatch discarded from trawl and purse seine fisheries are the predominant source of fish ingested by sea turtles in the NGOM. Fish ingestion by sea turtles is a relatively uncommon observation in Kemp's ridleys that strand in neighboring Florida, which has severely restricted the use of nets in its state waters but has many of the same potential non-fisheries sources of dead fish (e.g., algal blooms, hypoxic fish kills) found in other areas of GOM (Stacy, 2015).

Following compilation of a previous report on sea turtle stranding and necropsy findings for the NGOM (Stacy, 2015), a Sea Turtle Mortality Working Group was convened in 2014 to 1) obtain multidisciplinary, individual expert opinions regarding the cause(s) of sea turtle strandings within the NGOM region based on the review of available information; and 2) recommend additional investigation necessary to understand regional causes of sea turtle strandings. The recommendations provided by this group highlighted knowledge gaps in two key areas: the lack of sufficiently detailed temporospatial information on fisheries effort in the region and the need for studies of carcass drift to improve understanding of stranding patterns and backtracking capacity.

Significant progress has been made in some of these areas; however, evidence linking the sea turtle strandings to specific fisheries is lacking.

The commercial shrimp fishery and menhaden purse seine fishery are the most prolific net fisheries in this region; however, the seasonal trend in strandings does not align well with reported fisheries effort when stranding reports are highest. Various factors can contribute to such an apparent lack of correlation, such as those that affect the probability of interaction and mortality detection. Unfortunately, detailed temporospatial fisheries effort data remain nonexistent or unavailable, particularly for the commercial shrimp fishery and especially in state waters. Multiple projects are currently planned or under development that may help provide this information: 1) NOAA has funded daylight and nighttime vessel-based transect surveys for potential mortality locations prior to and during the peak stranding season. This effort was planned to begin in 2021 but was postponed to 2022 due to the COVID-19 pandemic and human health precautions. 2) A DWH Regionwide Trustee Implementation Group (TIG) restoration project aims to equip shrimp trawlers with Automatic Identification Systems (AISs), facilitating improved effort characterization. 3) Another DWH Regionwide TIG restoration project plans to develop an observer program for the Gulf menhaden fishery to study interactions with protected species.

There has been substantial progress in drift studies and hindcasting ability in the years following the Working Group recommendations. These studies have shown that the period of peak strandings in the NGOM correlates with conditions that favor beaching and that these conditions reverse with the onset of summer (Cook et al., 2021). Furthermore, higher decomposition and scavenging rates during the summer months decrease carcass persistence in the environment (Cook et al., 2021). Collectively, the results explain why strandings may not correlate well with fisheries effort. Backtracking analysis has identified possible locations where sea turtles without evident abnormalities may have died and suggest that most die within nearshore waters near stranding locations. In addition, forensic evaluation of sediment collected from the respiratory tracts of stranded turtles is being pursued as a possible indicator of locations where turtles died. These analyses are being used to help plan and target the types of direct surveillance studies necessary to investigate possible anthropogenic mortality sources.

Strandings with major injuries

Sea turtles with significant trauma were the second most frequent category of stranding (21.3%; 772/3,616) and were the most common finding in stranded green turtles. As in other areas of the US, wounds attributed to vessel strikes were by far the most common type of injury. Targeted conservation interventions that may benefit sea turtles include boater education and outreach and voluntary and regulatory go-slow zones (Fuentes et al., 2021). In Alabama, for example, efforts have been undertaken to increase educational signage and law enforcement presence around the seagrass beds of Perdido Pass to enforce existing no-motor and no-wake speed zones (Foundation, 2017).

The next most frequently noted injury type was shark bite wounds. A recent forensic study of shark bites on sea turtles stranded in the SE US found that many turtles found dead with shark bites resulted from scavenging (Stacy et al., 2021). Cook et al. (2021) also found that 69% of drift study carcasses had signs of scavenging. Therefore, at least some of these sea turtles more than likely died of other causes.

Other causes of injury included well-recognized threats to sea turtles, particularly interaction with fishing gear (hooking, entanglement, GI injury from ingestion) and anthropogenic marine debris.

Strandings in poor nutritional condition or with evidence of disease

This category comprised the smallest proportion (<4%; 131/3,616) of strandings in the NGOM. Conditions documented among these strandings were similar to those encountered in other stranding network areas, and the frequency of occurrence was comparable across all years of this report. Chronic exposure to petroleum and dispersant was a significant concern in the aftermath of the DWH oil spill. Although strandings may not be a sensitive indicator of delayed, persistent, or sublethal oil exposure effects, any changes in apparent health problems or emergence of previously unrecognized conditions would be a concern. Fortunately, we did not detect any such observable changes over the decade since the DWH spill.

In the previous 2015 report, we documented increasing proportions of stranded Kemp's ridleys with various degrees of fat atrophy in the years since the DWH spill. Continuation of the fat evaluation was recommended by the NGOM Sea Turtle Mortality Working Group as part of ongoing monitoring of sea turtle health (Stacy and Schroeder, 2016). Based on the last 5-years of data, findings indicate variation in the robustness of fat by year and season of stranding with a relative increase in fat atrophy from 2010 through 2015 that reversed in recent years when data are considered for the entire NGOM. However, greater proportions of stranded Kemp's ridleys found in Louisiana within the last 5-years, particularly those with a SCL between 25 and 45 cm, exhibited various degrees of fat atrophy, suggesting a trend of diminished nutritional condition has persisted in stranded Kemp's ridleys in that state. To our knowledge, this approach to the characterization of the nutritional status of stranded sea turtles using fat condition is relatively novel. Thus, we cannot compare our observations to other species and regions. Although we documented a remarkable variation in the robustness of fat over time, the degree of atrophy we observed in most turtles was still within the bounds of "normal variation" for the nutritional condition of free-ranging, healthy

Kemp's ridleys. Notably, we did not observe greater numbers of emaciated turtles in the years following the DWH spill.

Numerous possible factors could influence fat in wild sea turtles, including changes in prey abundance, prey availability, and environmental conditions. Interestingly, researchers reported evidence of reduced growth rates in the NGOM beginning in 2012 based on skeletochronology of humeri, including those collected from many of the Kemp's ridleys in this report (Ramirez et al., 2020). They speculated that this change was linked to possible food web effects of the DWH spill. Reduced robustness of fat plausibly reflects the same factors that would manifest as lower growth rates. In addition to the possible impacts of the DWH spill, there was a collapse of the Mississippi blue crab fishery, an important prey species for Kemp's ridleys and loggerheads, in 2011 that was attributed to freshwater intrusion from the BCS (GSMFC 2015). Understanding linkages between prey and nutritional condition of sea turtles is complicated by the various potential factors that influence prey populations, limited understanding of abundance for many prey species, and the contemporary diet of Kemp's ridleys in the NGOM which includes a significant proportion of fish carrion.

Other considerations related to sea turtle strandings in the NGOM

Freshwater diversions

Repeated freshwater diversions from the BCS are concerning with regard to possible effects on sea turtles, particularly their habitat and prey. Sea turtle strandings are unlikely to be a sensitive indicator of these types of effects. We did not observe any correlation between the spillway openings and strandings, nor were immediate effects anticipated, particularly deaths of sea turtles. Wild sea turtles frequent low salinity areas during their natural movements and foraging, e.g., (Metz, 2004; Seney and Landry, 2011; Chambault et al., 2016). In addition, there are multiple instances of captive large immature or adult sea turtles (loggerhead, hawksbill, and green turtles) having no apparent clinical effect following prolonged freshwater exposure (Stacy and Moore, pers obs.). There is evidence that surface-pelagic juveniles may be sensitive to low salinity conditions in captivity (Stacy, 2012), and there has been at least one incident of a green turtle developing hyponatremia (low blood sodium) following months-long entrapment in a golf course pond (Flanagan pers. com.). However, these situations involved potentially aggravating circumstances, such as concurrent parenteral fluid therapy and lack of dietary salt. In addition, as discussed in the next section, we also did not find conclusive evidence of exposure to biotoxins produced by cyanobacterium blooms attributed to the BCS releases in 2019.

Changes in nutritional conditions could be observed if sea turtles in areas affected by freshwater diversions experience a reduction of prey quality or availability. Crustaceans, particularly blue crab, are affected by salinity and were frequent in fecal samples from Kemp's ridleys caught on MS sound fishing piers prior to 2016 (Pitchford et al., 2016). Moreover, it is conceivable that reduced prey availability could drive turtles to consume alternative food sources, such as fish carrion. Although effects of water management on sea turtle habitat and diet should be considered, we did not observe any changes in the robustness of body fat among stranded Kemp's ridleys in Mississippi over the last 10 years.

Harmful algal blooms

We did not find evidence that HABs contributed to sea turtle strandings in Alabama, Mississippi, or Louisiana during the last decade. Biotoxins produced by harmful algae were not detected at concentrations expected to cause acute mortality of megavertebrates in any of the previous samples from 40 NGOM turtles (Stacy, 2015). Furthermore, the timing of the arrival of the *Karenia brevis* bloom (red tide) in Alabama and Mississippi during the winter of 2015/16 limited any potential exposure as sea turtles typically move out of near-shore waters during this period. Very low microcystin concentrations were detected in some turtles stranded during the severe cyanobacterium bloom in MS (2019), but definitive analytical methods could not confirm these results. In addition, stranding rates remained consistent with historical trends over this time. These observations are similar to our findings in Florida during recent cyanobacterium blooms in that state. Although we did not observe the obvious effects of HABs on stranded sea turtles in the NGOM during this period, HABs remain a known threat to sea turtle health and warrant continued monitoring.

Conclusions

The STSSN within the NGOM has undergone significant advances within the last 10 years through the improved organization, expansion of its constituent participants, public outreach and education, increased surveillance of remote areas, and pursuit of research and analytical tools that help us better understand stranding patterns and trends. The numbers of stranded sea turtles have significantly reduced within the most recent 5-yr period, concurrent with a marked reduction in the number of turtles caught by recreational anglers. These decreases suggest that there may have been a regional change in sea turtle distribution and/or abundance over this period that remains unexplained. As many aspects of sea turtle life history and movements can be dynamic over time, the STSSN must continue and further improve to understand this trend as it is followed into the coming years.

The predominant findings and identified causes of sea turtle stranding in the NGOM have remained similar over the last decade. These findings include significant numbers of turtles, particularly Kemp's ridleys, which appear to be relatively healthy sea turtles that drowned. These cases present as a predictable seasonal peak during the spring months that continues into summer. Most are moderately or severely decomposed, but we have excluded apparent non-anthropogenic causes such as death from HABs, disease, and traumatic injury. We now understand that the seasonality of strandings in the NGOM is explainable partly by environmental conditions that favor carcass beaching and detection. Furthermore, we have developed the capability to identify possible locations where turtles died that hopefully can be used to guide future surveillance efforts, help attribute these strandings to specific causes, and identify and implement measures to reduce these threats.

We also documented other anthropogenic threats to sea turtles similar to those encountered elsewhere, including vessel strikes and interaction with fishing gear/tackle and other forms of marine debris. Resource agencies and others can use these data to understand threats to sea turtles in the NGOM to develop and implement threat reduction measures.

Sea turtle populations in a changing Gulf

Significant events have impacted the northern Gulf of Mexico during the period of this report, including the historic *Deepwater Horizon* oil spill, numerous major storms, and water management actions that have periodically diverted large volumes of freshwater into areas of the Gulf ecosystem. The implications of these events for sea turtles, as well as their habitat and prey, are not fully understood. Stranding-based studies are one of our few direct means of monitoring and studying the health and mortality of sea turtles in the ocean. The focus of this report is proximate causes of stranding as investigated through evaluation of stranded animals, postmortem examination, and diagnostic analyses pertinent to cause of death determinations. However, there are additional worthwhile areas of ongoing or needed research that are beyond the scope of this report that may yield insight into trends and principal drivers of sea turtle strandings. Studies of sea turtle distribution and movements, prey species, habitat, and various factors that affect sea turtle health and fitness are examples of additional areas of study that may significantly advance our understanding of the ecology and health of Gulf sea turtle populations.

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Appendix A. Standard Reporting Forms

Sea Turtle Stranding and Salvage Network – Stranding Report

SEA TURTLE STRANDING AND SALVAGE NETWORK – STRANDING REPORT

OBSERVER'S NAME / ADDRESS / PHONE:
First ________________ M.I.____ Last ______________________
Affiliation ____
Address ____
____
Area code/Phone number _________________________________

STRANDING DATE:
Year 20☐☐ Month ☐☐Day☐☐
Turtle number by day ☐☐

Coordinator must be notified within 24 hrs; this was done by ☐***phone*** ☐***email*** ☐***fax***

SPECIES: (check one)
☐ CC = Loggerhead
☐ CM = Green
☐ DC = Leatherback
☐ EI = Hawksbill
☐ LK = Kemp's Ridley
☐ LO = Olive Ridley
☐ UN = Unidentified
Check Unidentified if not positive. Do Not Guess.

STRANDING LOCATION: ☐Offshore (Atlantic or Gulf beach) ☐Inshore (bay, river, sound, inlet, etc)
State ____________________ County/Parrish ____________________
Descriptive location (be specific) ______________________________
____
____
Latitude ____________________ Longitude ____________________

Carcass necropsied? ☐Yes☐No
Photos taken? ☐Yes ☐No
Species verified by coordinator?
☐ Yes ☐ No

CONDITION: (check one)
☐ 0 = Alive
☐ 1 = Fresh dead
☐ 2 = Moderately decomposed
☐ 3 = Severely decomposed
☐ 4 = Dried carcass
☐ 5 = Skeleton, bones only

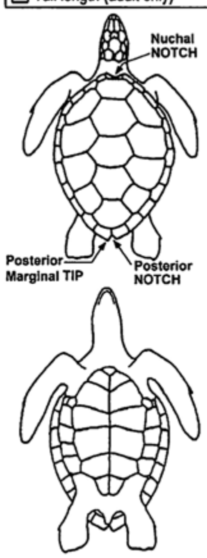
FINAL DISPOSITION: (check)
☐1 = Left on beach where found; painted? ☐Yes* ☐No(5)
☐2 = Buried: ☐ on beach / ☐ off beach;
carcass painted before buried? ☐ Yes* ☐ No
☐3 = Salvaged: ☐ all / ☐ part(s), what/why? ________
____
____
☐4 = Pulled up on beach/dune; painted? ☐Yes* ☐No
☐6 = Alive, released
☐7 = Alive, taken to rehab. facility, where? __________
____
☐8 = Left floating, not recovered; painted? ☐Yes* ☐No
☐9 = Disposition unknown, explain ______________
____
****If painted, what color?*** ______________________

SEX:
☐ Undetermined
☐ Female ☐ Male
Does tail extend beyond carapace?
☐ Yes; how far?_______ cm / in
☐ No
How was sex determined?
☐ Necropsy
☐ Tail length (adult only)

TAGS: *Contact coordinator before disposing of any tagged animal!!*
Checked for flipper tags? ☐ Yes ☐ No
Check all 4 flippers. If found, record tag number(s) / tag location / return address
____
____
____
PIT tag scan? ☐ Yes ☐ No
If found, record number / tag location
____
____
Coded wire tag scan? ☐ Yes ☐ No
If positive response, record location (flipper)
____
Checked for living tag? ☐Yes ☐ No
If found, record location (scute number & side)
____

CARAPACE MEASUREMENTS: (*see drawing*)

Using calipers		**Circle unit**
Straight length (NOTCH-TIP)	________	cm / in
Minimum length (NOTCH-NOTCH)	________	cm / in
Straight width (Widest Point)	________	cm / in
Using non-metal measuring tape		**Circle unit**
Curved length (NOTCH–TIP)	________	cm / in
Minimum length (NOTCH-NOTCH)	________	cm / in
Curved width (Widest Point)	________	cm / in
		Circle unit
Weight ☐ actual / ☐ est.	________	kg / lb



Mark wounds / abnormalities on diagrams at left and describe below (note tar or oil, gear or debris entanglement, propeller damage, epibiota, papillomas, emaciation, etc.). **Please note if no wounds / abnormalities are found.**
____
____
____
____
____
____

Gross Necropsy Report (2-Page)

SEA TURTLE STRANDING & SALVAGE NETWORK – GROSS NECROPSY REPORT (2-PAGE)

IDENTIFICATION

STSSN #: ______________________ **Other identifier(s)/#:** ______________________ **Rehab:** □Y □N

Found dead: □Y □N **If no, date of death** ____/____/______ leave blank if unknown (Use mm/dd/yyyy for dates)

Euthanized: □Y □N **Frozen/Thawed:** □Y □N **Condition at necropsy:** □1 □2 □3 □4 □5

Date necropsied: ____/____/______ **Examiner:** ________________ **Affiliation:** ______________________

Necropsy description: □External & internal examination □External examination only □Incomplete carcass

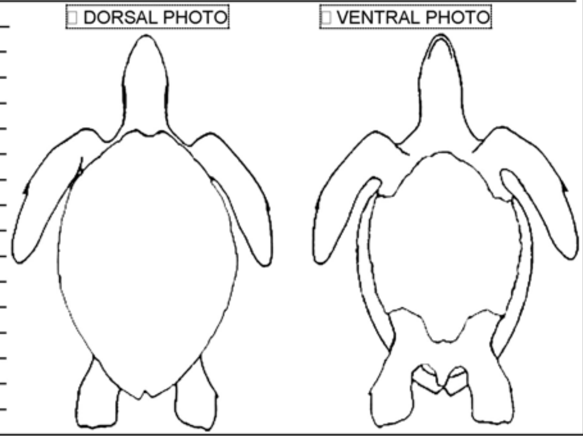
Disposition of carcass: □Buried on beach □Buried off site □Rendered □Incinerated □Other

Species: □CC □CM □DC □LK □EI □LO □HYBRID □UNK **Sex:** □Male □Female □Undetermined

SUMMARY COMMENT SECTION & DIAGRAM

Comments / Summary of findings: *Please summarize your findings: include any injuries, obvious major abnormalities, nutritional condition, and review of digestive contents. For example: 1. Parallel chop wounds with blood clots; 2. Abundant fat; 3. Crab shell in stomach and intestine.*

□ DORSAL PHOTO □ VENTRAL PHOTO



SPECIMEN COLLECTION INVENTORY

Specimen (label w/ ID#)	Fixed	Frozen-bagged	Frozen-Foil	Other (specify)	Location

ANATOMIC LOCATION CODES: Head (H) Neck(N) Eyes(E) Mouth(M) Carapace(C) Plastron(P) Tail(T) Vent(V)
Front flipper - Right(R) Left(L) Rear flipper - Right(F) Left(G) All appendages(Y) Pectoral girdle(J) Pelvis(I) Esophagus(Es)
Stomach(St) Small intestine(Si) Colon(Co) Cloaca(Cl)
Enter anatomic codes after numbered entries and by applicable descriptors in shaded areas on the next page

Examples: X1-Parallel chop wounds HC
XHook(s) M XHemorrhage1HC

EXTERNAL INJURIES: ☐Y ☐N ☐CBD ☐ PHOTO w/ scale

☐1-Parallel chop wounds_____ ☐2-Single linear/chop wound_____ ☐3-Blunt/crushing_____ ☐4-Amputation____
☐ 5-Entangle-type_____ ☐6-Penetrating_____ ☐7-Bite wound _____ ☐8-Incised/mutilation_____ ☐9-Other____

☐Hemorrhage___ ☐Exudate/fibrin___ ☐Partial healing___ ☐Completely healed___ ☐None___ ☐CBD___
☐Coelom breached___ ☐Brain/spinal cord damaged___ ☐Lung exposed___ ☐Other organs exposed___ ☐CBD__

MAN-MADE MATERIAL: ☐Y ☐N ☐Assoc with injury? If yes, enter the above number(s) here:_______ *(e.g., 5)* ☐Saved?

☐Hook(s)____ ☐Monofilament line____ ☐Multifilament line(≤1mm) ____ ☐Multifilament line(>1mm) _____ ☐Buoy____
☐Netting____ ☐Trap ____ ☐Oil ____ ☐Other____ ☐ PHOTO w/ scale

OTHER EXTERNAL ANOMALIES: ☐Y ☐N ☐CBD ☐ PHOTO

☐ Heavily encrusted w/ epibiota ☐ Leeches: ☐Few ☐Many ☐Gooseneck barnacles

☐FP_______: ☐Papillary texture? ☐On eyes? ☐In mouth? FP severity (circle): 1 2 3

☐Ulceration/dermatitis_______: ☐Superficial crusts- ☐*few/small* ☐*extensive* ☐Deep/ulcerated- ☐ *few/small* ☐*extensive*

☐Masses (non-FP or uncertain)______ ☐Other_________

External Findings Comments: *(include any entries of "Other" & description of any man-made material)*

MUSCLE STATUS: ☐Well-muscled/No atrophy ☐Partially atrophy ☐Severe atrophy ☐CBD

FAT STATUS: ☐Abundant/No atrophy ☐Partial atrophy ☐Severe atrophy(depleted) ☐CBD ☐ PHOTO

COELOM: ☐No findings ☐Exudate/fibrin ☐Blood clots ☐Encysted parasites ☐Organs pale ☐Other ☐CBD

Comments: ☐ **Internal FP?** *(list locations under comments)*

HEART & MAJOR VESSELS: ☐No findings ☐Trauma ☐Thickened vessels ☐Other ☐CBD

Comments: **Blood in heart chambers:** ☐Y ☐N ☐CBD

LIVER & GALL BLADDER: ☐No findings ☐Atrophy (shrunken, black) ☐Trauma ☐Other ☐CBD

Comments:

GI TRACT: ☐No findings ☐Abnormal ☐Ingested fish ☐Ingested shrimp ☐CBD ☐ **Mouth examined?**

☐10-Ulcers/exudate____ ☐11-Trauma/perforation____ ☐12- Obstruction/blockage_____ ☐13-Intussusception_____
☐14-Plication ______ ☐15-Fluke eggs_____ ☐16-Other______

☐<5% affected____ ☐5-25%____ ☐>25-50%____ ☐>50%____ ☐N/A

MAN-MADE MATERIAL: ☐Y ☐N ☐Assoc with injury? If yes, enter the number(s) here:_____ *(e.g., 14)* ☐Saved? ☐ PHOTO w/ scale

Mouth/esophagus: ☐Empty ☐Contents (describe): ____________________

Stomach: ☐Empty ☐Contents (describe): ____________________

Intestine (first ½): ☐Empty ☐Contents (describe): ____________________

Intestine (last ½): ☐Empty ☐Contents (describe): ____________________

Comments: *(include any entries of "Other" & description of any man-made material)*

UROGENITAL: ☐No findings ☐Abnormal ☐Shelled eggs ☐Follicles ≥2cm ☐CBD

Comments: **Sex:** ☐Male ☐Female ☐Unk

RESP: Trachea/bronchi: ☐No findings ☐Some froth ☐Copious froth ☐Sand/sediment ☐Trauma ☐Exudate ☐CBD

Lungs: ☐No findings ☐Wet/frothy ☐Sand/sediment ☐Trauma ☐Exudate ☐Other ☐CBD

Comments:

BRAIN & SPINAL CORD: ☐No findings ☐Trauma ☐Hemorrhage ☐Exudate ☐Fluke eggs ☐Other ☐CBD

Comments:

Appendix B. Supplemental Tables

Supplementary Table B-1. Numbers of sea turtles reported stranded, photo-documented, and necropsied within the northern Gulf of Mexico by species and 5-year period.

Species		Stranded	Photo confirmation	Necropsies
Kemp's ridley				
	2010–2014	2,073	2,015 (97.2%)	1,255 (60.5%)
	2015–2019	870	868 (99.8%)	419 (48.2%)
	Total	2,943	2,883 (98.0%)	1,674 (56.9%)
Loggerhead				
	2010–2014	139	126 (90.6%)	65 (46.8%)
	2015–2019	172	170 (98.8%)	53 (30.8%)
	Total	311	296 (95.2%)	118 (37.9)
Green turtle				
	2010–2014	102	97 (95.1%)	66 (64.7%)
	2015–2019	100	100 (100.0%)	46 (46.0%)
	Total	202	197 (97.5%)	112 (55.4%)
Leatherback				
	2010–2014	7	7 (-)	3 (-)
	2015–2019	3	3 (-)	0
	Total	10	10 (100%)	3 (30.0%)
Hawksbill				
	2010–2014	2	1 (-)	1 (-)
	2015–2019	0	0 (-)	0 (-)
	Total	2	1 (-)	1 (-)
Undetermined				
	2010–2014	85	21 (24.7%)	0 (0%)
	2015–2019	65	29 (44.6%)	2 (3.1%)
	Total	150	50 (33.3%)	2 (1.3%)
All species				
	2010–2014	2,408	2,267 (94.1%)	1,390 (57.7%)
	2015–2019	1,210	1,170 (96.7%)	519 (42.9%)
	Total	3,618	3,437 (95.0%)	1,909 (52.8%)

Supplementary Table B-2. Numbers of stranded and necropsied sea turtles in Alabama by species and 5-year period.

Species		Stranded	Necropsies
Kemp's ridley			
	2010–2014	322	165 (51.2%)
	2015–2019	179	77 (43.0%)
	Total	501	242
Loggerhead			
	2010–2014	37	13 (35.1%)
	2015–2019	54	20 (37.0%)
	Total	91	33 (36.3%)
Green turtle			
	2010–2014	21	7 (33.3%)
	2015–2019	25	10 (40.0%)
	Total	46	17 (37.0%)
Leatherback			
	2010–2014	3	0 (-)
	2015–2019	2	0 (-)
	Total	5	0 (-)
Hawksbill			
	2010–2014	2	1 (-)
	2015–2019	0	0 (-)
	Total	2	1 (-)
Undetermined			
	2010–2014	20	0 (0%)
	2015–2019	10	0 (0%)
	Total	30	0 (0%)
All species			
	2010–2014	405	186 (45.9%)
	2015–2019	270	107 (39.6%)
	Total	675	293 (43.4%)

Supplementary Table B-3. Condition of stranded sea turtles from Alabama by species and 5-year period.

Species	Alive	Mildly decomposed	Moderately decomposed	Severely decomposed	Desiccated or skeletal remains	Unknown	Total
Kemp's ridley							
2010–2014	16 (5.0%)	10 (3.1%)	156 (48.4%)	118 (36.6%)	19 (5.9%)	3 (0.9%)	322
2015–2019	10 (5.6%)	6 (3.4%)	74 (41.3%)	73 (40.8%)	16 (8.9%)	0 (0%)	179
Total	26 (5.2%)	16 (3.2%)	230 (45.9%)	191 (38.1%)	35 (7.0%)	3 (0.6%)	501
Loggerhead							
2010–2014	5 (13.5%)	3 (8.1%)	16 (43.2%)	12 (32.4%)	1 (2.7%)	0 (0%)	37
2015–2019	7 (13.0%)	4 (7.4%)	22 (40.7%)	20 (37.0%)	1 (1.9%)	0 (0%)	54
Total	12 (13.2%)	7 (7.7%)	38 (41.8%)	32 (35.2%)	2 (2.2%)	0 (0%)	91
Green turtle							
2010–2014	1 (4.8%)	3 (14.3%)	8 (38.1%)	8 (38.1%)	1 (4.8%)	0 (0%)	21
2015–2019	4 (16.0%)	4 (16.0%)	9 (36.0%)	8 (32.0%)	0 (0%)	0 (0%)	25
Total	5 (10.9%)	7 (15.2%)	17 (37.0%)	16 (34.8%)	1 (2.2%)	0 (0%)	46
Leatherback							
2010–2014	0 (-)	0 (-)	0 (-)	3 (-)	0 (-)	0 (-)	3
2015–2019	0 (-)	0 (-)	1 (-)	1 (-)	0 (-)	0 (-)	2
Total	0 (-)	0 (-)	1 (-)	4 (-)	0 (-)	0 (-)	5
Hawksbill							
2010–2014	2 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	2
2015–2019	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
Total	2 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	2
Undetermined							
2010–2014	0 (0%)	0 (0%)	0 (0%)	1 (5.0%)	3 (15.0%)	16 (80.0%)	20
2015–2019	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2 (20.0%)	8 (80.0%)	10
Total	0 (0%)	0 (0%)	0 (0%)	1 (3.3%)	5 (16.7%)	24 (80.0%)	30
All species							
2010–2014	24 (5.9%)	16 (4.0%)	180 (44.4%)	142 (35.1%)	24 (5.9%)	19 (4.7%)	405
2015–2019	21 (7.8%)	14 (5.2%)	106 (39.3%)	102 (37.8%)	19 (7.0%)	8 (3.0%)	270
Total	45 (6.7%)	30 (4.4%)	286 (42.4%)	244 (36.1%)	43 (6.4%)	27 (4.0%)	675

Supplementary Table B-4. Location of sediment within the respiratory tract for necropsied sea turtles from Alabama by species, 5-year period, and stranding category.

Species	Sediment in trachea/bronchi	Sediment in lungs
Green turtle		
2010–2014		
No anomalies	0/0 (-)	0/0 (-)
Trauma	0/4 (-)	0/4 (-)
Disease	0/1 (-)	0/1 (-)
Total	0/5 (-)	0/5 (-)
2015–2019		
No anomalies	1/2 (-)	1/2 (-)
Trauma	4/7 (-)	1/7 (-)
Disease	0/1 (-)	0/1 (-)
Total	5/10 (50.0%)	2/10 (20.0%)
Kemp's ridley		
2010–2014		
No anomalies	30/66 (45.5%)	29/64 (45.3%)
Trauma	5/45 (11.1%)	3/45 (6.7%)
Disease	1/5 (-)	2/5 (-)
Total	36/116 (31.0%)	34/114 (29.8%)
2015–2019		
No anomalies	16/49 (32.7%)	15/49 (30.6%)
Trauma	3/16 (18.8%)	1/16 (6.3%)
Disease	0/1 (-)	0/1 (-)
Total	19/69 (27.5%)	16/66 (24.2%)
Loggerhead		
2010–2014		
No anomalies	0/4 (-)	1/4 (-)
Trauma	0/3 (-)	0/3 (-)
Disease	1/1 (-)	1/1 (-)
Total	1/8 (-)	2/8 (-)
2015–2019		
No anomalies	1/8 (-)	1/8 (-)
Trauma	0/1 (-)	0/1 (-)
Disease	0/10 (0%)	2/10 (0%)
Total	1/19 (5.3%)	3/19 (15.8%)

Supplementary Table B-5. Digestive contents of stranded sea turtles in Alabama by species, 5-year period, and stranding category.

Species	Food in mouth / esophagus	Food in stomach	Ingested fish	Ingested shrimp
Kemp's ridley				
2010–2014				
No anomalies	17/68 (25.0%)	56/65 (86.2%)	55/68 (80.9%)	4/65 (6.2%)
Trauma	9/56 (16.1%)	29/45 (64.4%)	23/47 (48.9%)	1/46 (2.2%)
Disease	0/5 (-)	3/5 (-)	2/5 (-)	0/5 (-)
Total	26/129 (20.2%)	88/115 (76.5%)	80/120 (66.7%)	5/116 (4.3%)
2015–2019				
No anomalies	8/50 (16.0%)	34/50 (68.0%)	23/53 (43.4%)	3/53 (5.7%)
Trauma	2/14 (14.3%)	8/14 (57.1%)	10/15 (66.7%)	4/15 (26.7%)
Disease	0/1 (-)	1/1 (-)	0/1 (-)	0/1 (-)
Total	10/65 (15.4%)	43/65 (66.2%)	33/69 (47.8%)	7/69 (10.1%)
Loggerhead				
2010–2014				
No anomalies	1/5 (-)	2/5 (-)	1/5 (-)	0/5 (-)
Trauma	1/3 (-)	2/3 (-)	0/3 (-)	0/3 (-)
Disease	0/1 (-)	0/1 (-)	0/1 (-)	0/1 (-)
Total	2/9 (-)	4/9 (-)	1/9 (-)	0/9 (-)
2015–2019				
No anomalies	1/6 (-)	2/7 (-)	1/8 (-)	1/8 (-)
Trauma	0/1 (-)	0/1 (-)	0/1 (-)	0/1 (-)
Disease	0/8 (-)	1/8 (-)	0/8 (-)	0/8 (-)
Total	1/15 (6.6%)	3/16 (18.8%)	1/17 (5.9%)	0/17 (0%)
Green turtle				
2010–2014				
No anomalies	0/0 (-)	0/0 (-)	0/0 (-)	0/0 (-)
Trauma	3/6 (-)	5/5 (-)	1/4 (-)	0/4 (-)
Disease	0/1(-)	1/1 (-)	0/1 (-)	0/1 (-)
Total	3/7 (-)	6/6 (-)	1/5 (-)	0/5 (-)
2015–2019				
No anomalies	2/2 (-)	1/2 (-)	0/2 (-)	0/2 (-)
Trauma	4/7 (-)	6/6 (-)	0/7 (-)	0/7 (-)
Disease	0/1 (-)	1/1 (-)	0/1 (-)	0/1 (-)
Total	6/10 (60.0%)	8/9 (-)	0/10 (0%)	0/10 (0%)

Supplementary Table B-6. Numbers of stranded and necropsied sea turtles in Mississippi by species and 5-year period.

Species		Stranded	Necropsies
Kemp's ridley			
	2010–2014	1,071	509 (47.5%)
	2015–2019	469	219 (46.7%)
	Total	1,540	728 (47.3%)
Loggerhead			
	2010–2014	51	15 (29.4%)
	2015–2019	81	17 (21.0%)
	Total	132	32 (24.2%)
Green turtle			
	2010–2014	19	7 (36.8%)
	2015–2019	21	9 (42.9%)
	Total	40	16 (40.0%)
Leatherback			
	2010–2014	1	0 (-)
	2015–2019	0	0 (-)
	Total	1	0 (-)
Hawksbill			
	2010–2014	0	0 (-)
	2015–2019	0	0 (-)
	Total	0	0 (-)
Undetermined			
	2010–2014	23	0 (0%)
	2015–2019	30	0 (0%)
	Total	53	0 (0%)
All species			
	2010–2014	1,164	531 (45.6%)
	2015–2019	601	245 (40.8%)
	Total	1,765	776 (44.0%)

Supplementary Table B-7. Condition of stranded sea turtles from Mississippi by species and 5-year period.

Species	Alive	Mildly decomposed	Moderately decomposed	Severely decomposed	Desiccated or skeletal remains	Unknown	Total
Kemp's ridley							
2010–2014	19 (1.8%)	31 (2.9%)	286 (26.7%)	630 (58.8%)	103 (9.6%)	2 (0.2%)	1,071
2015–2019	9 (1.9%)	7 (1.5%)	186 (39.7%)	244 (52.0%)	23 (4.9%)	0 (0%)	469
Total	28 (1.8%)	38 (2.5%)	472 (30.6%)	874 (56.8%)	126 (8.2%)	2 (0.1%)	1,540
Loggerhead							
2010–2014	3 (5.9%)	2 (3.9%)	12 (23.5%)	28 (54.9%)	6 (11.8%)	0 (0%)	51
2015–2019	2 (2.5%)	2 (2.5%)	17 (21.0%)	49 (60.5%)	9 (11.1%)	2 (2.5%)	81
Total	5 (3.8%)	4 (3.0%)	29 (22.0%)	77 (58.3%)	15 (11.4%)	2 (1.5%)	132
Green turtle							
2010–2014	0 (0%)	3 (15.8%)	4 (21.1%)	9 (47.4%)	3 (15.8%)	0 (0%)	19
2015–2019	1 (4.8%)	0 (-)	8 (38.1%)	10 (47.6%)	2 (9.5%)	0 (0%)	21
Total	1 (2.5%)	3 (7.5%)	12 (30.0%)	19 (47.5%)	5 (12.5%)	0 (0%)	40
Leatherback							
2010–2014	0 (-)	0 (-)	0 (-)	1 (-)	0 (-)	0 (-)	1
2015–2019	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
Total	0 (-)	0 (-)	0 (-)	1 (-)	0 (-)	0 (-)	1
Hawksbill							
2010–2014	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
2015–2019	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
Total	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
Undetermined							
2010–2014	1 (4.3%)	0 (0%)	1 (4.3%)	5 (21.7%)	14 (60.9%)	2 (8.7%)	23
2015–2019	0 (0%)	1 (3.3%)	2 (6.7%)	9 (30.0%)	13 (43.3%)	5 (16.7%)	30
Total	1 (1.9%)	1 (1.9%)	3 (5.7%)	14 (26.4%)	27 (50.9%)	7 (13.2%)	53
All species							
2010–2014	23 (2.0%)	36 (3.1%)	303 (26.0%)	673 (57.8%)	126 (10.8%)	4 (0.3%)	1,165
2015–2019	12 (2.0%)	10 (1.7%)	213 (35.4%)	312 (51.9%)	47 (7.8%)	7 (1.2%)	601
Total	35 (2.0%)	46 (2.6%)	516 (29.2%)	985 (55.8%)	173 (9.8%)	11 (0.6%)	1,766

Supplementary Table B-8. Location of sediment within the respiratory tract for necropsied sea turtles from Mississippi by species, stranding category, and 5-year period.

Species	Sediment in trachea/bronchi	Sediment in lungs
Kemp's ridley		
2010–2014		
No anomalies	124/272 (45.6%)	70/271 (25.8%)
Trauma	12/64 (18.8%)	3/63 (4.8%)
Disease	9/22 (40.9%)	7/21 (33.3%)
Total	145/358 (40.5%)	80/355 (22.5%)
2015–2019		
No anomalies	90/164 (54.9%)	48/164 (29.3%)
Trauma	3/11 (27.3%)	1/11 (9.1%)
Disease	1/4 (-)	1/4 (-)
Total	94/179 (52.5%)	50/179 (27.9%)
Loggerhead		
2010–2014		
No anomalies	1/1 (-)	0/1 (-)
Trauma	2/7 (-)	0/7 (-)
Disease	1/3 (-)	0/3 (-)
Total	4/11 (36.4%)	0/11 (0%)
2015–2019		
No anomalies	5/11 (45.5%)	4/11 (36.4%)
Trauma	1/1 (-)	0/1 (-)
Disease	1/3 (-)	1/3 (-)
Total	7/17 (41.2%)	5/15 (33.3%)
Green turtle		
2010–2014		
No anomalies	0/0 (-)	0/0 (-)
Trauma	0/2 (-)	0/2 (-)
Disease	0/0 (-)	0/0 (-)
Total	0/2 (-)	0/2 (-)
2015–2019		
No anomalies	0/3 (-)	0/3 (-)
Trauma	1/3 (-)	1/3 (-)
Disease	0/0 (-)	0/0 (-)
Total	1/6 (-)	1/6 (-)

Supplementary Table B-9. Digestive contents of stranded sea turtles in Mississippi by species, 5-year period, and stranding category.

Species	Food in mouth / esophagus	Food in stomach	Ingested fish	Ingested shrimp
Kemp's ridley				
2010–2014				
No anomalies	51/311 (16.4%)	228/300 (76.0%)	267/314 (85.0%)	28/309 (9.1%)
Trauma	5/83 (6.0%)	27/55 (49.1%)	25/59 (42.4%)	1/38 (2.6%)
Disease	2/26 (7.7%)	12/26 (46.2%)	20/26 (76.9%)	2/26 (7.7%)
Total	59/420 (14.0%)	267/381 (70.1%)	312/399 (78.2%)	31/391 (7.9%)
2015–2019				
No anomalies	30/175 (17.1%)	129/170 (75.9%)	146/180 (81.1%)	1/180 (0.6%)
Trauma	4/12 (33.3%)	8/13 (61.5%)	6/13 (46.2%)	0/13 (0%)
Disease	1/4 (-)	2/4 (-)	3/4 (-)	0/4 (-)
Total	35/191 (18.3%)	139/187 (74.3%)	155/197 (78.7%)	1/197(0.5%)
Loggerhead				
2010–2014				
No anomalies	0/0 (-)	0/0 (-)	1/1 (-)	0/1 (-)
Trauma	3/6 (-)	0/4 (-)	0/4 (-)	0/4 (-)
Disease	0/3 (-)	0/3 (-)	0/3 (-)	0/3 (-)
Total	3/9 (-)	0/7 (-)	1/8 (-)	0/8 (-)
2015–2019				
No anomalies	2/11 (18.2%)	6/10 (60.0%)	9/10 (90.0%)	0/10 (0%)
Trauma	0/1 (-)	1/1 (-)	0/1 (-)	0/1 (-)
Disease	0/3 (-)	1/3 (-)	0/3 (-)	0/3 (-)
Total	2/15 (13.3%)	8/14 (57.1%)	9/14 (64.3%)	0/14 (0%)
Green turtle				
2010–2014				
No anomalies	0/0 (-)	0/0 (-)	0/0 (-)	0/0 (-)
Trauma	2/4 (-)	3/3 (-)	0/2 (-)	0/2 (-)
Disease	0/0 (-)	0/0 (-)	0/0 (-)	0/0 (-)
Total	2/4 (-)	3/3 (-)	0/2 (-)	0/2 (-)
2015–2019				
No anomalies	2/3 (-)	3/3 (-)	0/3 (-)	0/3 (-)
Trauma	2/3 (-)	1/2 (-)	0/3 (-)	0/3 (-)
Disease	0/0 (-)	0/0 (-)	0/0 (-)	0/0 (-)
Total	4/6 (-)	4/5 (-)	0/6 (-)	0/6 (-)

Supplementary Table B-10. Numbers of stranded and necropsied sea turtles in Louisiana by species and 5-year period.

Species		Stranded	Necropsies
Kemp's ridley			
	2010–2014	680	582 (85.6%)
	2015–2019	222	121 (54.5%)
	Total	902	703 (77-9%)
Loggerhead			
	2010–2014	51	37 (72.5%)
	2015–2019	37	14 (37.8%)
	Total	88	51 (58.0%)
Green turtle			
	2010–2014	62	52 (83.9%)
	2015–2019	54	27 (50.0%)
	Total	116	79 (68.1%)
Leatherback			
	2010–2014	3	3 (-)
	2015–2019	1	0 (-)
	Total	4	3 (-)
Hawksbill			
	2010–2014	0	0 (-)
	2015–2019	0	0 (-)
	Total	0	0 (-)
Undetermined			
	2010–2014	42	1 (2.4%)
	2015–2019	25	1 (4.0%)
	Total	67	2 (3.0%)
All species			
	2010–2014	838	675 (80.5%)
	2015–2019	339	163 (48.1%)
	Total	1,177	838 (71.2%)

Supplementary Table B-11. Postmortem condition of stranded sea turtles from Louisiana by species and 5-year period.

Species	Alive	Mildly decomposed	Moderately decomposed	Severely decomposed	Desiccated or skeletal remains	Unknown	Total
Kemp's ridley							
2010–2014	15 (2.2%)	24 (3.5%)	290 (42.6%)	257 (37.8%)	84 (12.4%)	10 (1.5%)	680
2015–2019	4 (1.8%)	4 (1.8%)	70 (31.5%)	104 (46.8%)	40 (18.0%)	0 (0%)	222
Total	19 (2.1%)	28 (3.1%)	360 (39.9%)	361 (40.0%)	124 (13.7%)	10 (1.1%)	902
Loggerhead							
2010–2014	3 (5.9%)	5 (9.8%)	11 (21.6%)	19 (37.3%)	13 (25.5%)	0 (0%)	51
2015–2019	3 (8.1%)	1 (2.7%)	10 (27.0%)	17 (45.9%)	6 (16.2%)	0 (0%)	37
Total	6 (6.8%)	6 (6.8%)	21 (23.9%)	36 (40.9%)	19 (21.6%)	0 (0%)	88
Green turtle							
2010–2014	4 (6.5%)	9 (14.5%)	21 (33.9%)	21 (33.9%)	6 (9.7%)	1 (1.6%)	62
2015–2019	6 (11.1%)	3 (5.6%)	25 (46.3%)	9 (16.7%)	11 (20.4%)	0 (0%)	54
Total	10 (8.6%)	12 (10.3%)	46 (39.7%)	30 (25.9%)	17 (14.7%)	1 (0.9%)	116
Leatherback							
2010–2014	0 (-)	0 (-)	0 (-)	3 (-)	0 (-)	0 (-)	3
2015–2019	0 (-)	0 (-)	1 (-)	0 (-)	0 (-)	0 (-)	1
Total	0 (-)	0 (-)	1 (-)	3 (-)	0 (-)	0 (-)	4
Hawksbill							
2010–2014	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
2015–2019	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
Total	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0 (-)	0
Undetermined							
2010–2014	3 (7.1%)	2 (4.8%)	3 (7.1%)	10 (23.8%)	11 (26.2%)	13 (31.0%)	42
2015–2019	1 (4.0%)	0 (0%)	3 (12.0%)	2 (8.0%)	5 (20.0%)	14 (56.0%)	25
Total	4 (6.0%)	2 (3.0%)	6 (9.0%)	12 (17.9%)	16 (23.9%)	27 (40.3%)	67
All species							
2010–2014	25 (3.0%)	40 (4.8%)	325 (38.8%)	310 (37.0%)	114 (13.6%)	24 (2.9%)	838
2015–2019	14 (4.1%)	8 (2.4%)	109 (32.2%)	132 (38.9%)	62 (18.3%)	14 (4.1%)	339
Total	39 (3.3%)	48 (4.1%)	434 (36.9%)	442 (37.6%)	176 (15.0%)	38 (3.2%)	1,177

Supplementary Table B-12. Location of sediment within the respiratory tract for necropsied sea turtles from Louisiana by species and stranding category.

Species		Sediment in trachea/bronchi	Sediment in lungs
Kemp's ridley			
2010–2014			
	No injuries	99/173 (57.2%)	73/167 (43.7%)
	Trauma	14/48 (29.2%)	14/49 (28.6%)
	Disease	3/10 (30.0%)	1/10 (10.0%)
	Total	116/231 (50.2%)	88/226 (38.9%)
2015–2019			
	No injuries	18/43 (41.9%)	14/43 (32.6%)
	Trauma	1/5 (-)	0/5 (-)
	Disease	0/0 (-)	0/0 (-)
	Total	19/48 (39.6%)	14/48 (29.2%)
Loggerhead			
2010–2014			
	No injuries	3/7 (-)	4/7 (-)
	Trauma	1/3 (-)	1/3 (-)
	Disease	1/5 (-)	2/5 (-)
	Total	5/15 (33.3%)	7/15 (46.7%)
2015–2019			
	No injuries	2/4 (-)	4/4 (-)
	Trauma	0/0 (-)	0/0(-)
	Disease	1/2 (-)	1/2 (-)
	Total	3/6 (-)	5/6 (-)
Green turtle			
2010–2014			
	No injuries	1/3 (-)	0/4 (-)
	Trauma	3/14 (21.4%)	2/14 (14.3%)
	Disease	0/1 (-)	0/1 (-)
	Total	4/19 (21.1%)	2/19 (10.5%)
2015–2019			
	No injuries	0/5 (-)	0/5(-)
	Trauma	2/7 (-)	0/7 (-)
	Disease	0/0 (-)	0/0 (-)
	Total	2/12 (16.7%)	0/12 (0%)

Supplementary Table B-13. Digestive contents of stranded sea turtles in Louisiana by species, 5-year period, and stranding category.

Species	Food in mouth / esophagus	Food in stomach	Ingested fish	Ingested shrimp
Kemp's ridley				
2010–2014				
No injuries	56/269 (20.8%)	201/243 (82.7%)	205/261 (78.5%)	31/251 (12.4%)
Trauma	8/93 (8.6%)	54/63 (85.7%)	48/78 (61.5%)	5/63 (7.9%)
Disease	0/13 (0%)	8/13 (61.5%)	9/14 (64.3%)	0/12 (0%)
Total	64/375 (17.1%)	264/319 (82.8%)	262/353 (74.2%)	36/326 (11.0%)
2015–2019				
No injuries	9/56 (16.1%)	45/60 (75.0%)	52/69 (75.4%)	6/69 (8.7%)
Trauma	3/10 (30.0%)	5/8 (-)	5/8 (-)	0/8 (-)
Disease	0/0 (-)	0/0 (-)	0/0 (-)	0/0 (-)
Total	12/66 (18.2%)	50/68 (73.5%)	57/77 (74.0%)	6/77 (7.8%)
Loggerhead				
2010–2014				
No injuries	3/9 (-)	6/9 (-)	6/11 (54.5%)	0/9 (-)
Trauma	0/4 (-)	2/5 (-)	0/5 (-)	0/5 (-)
Disease	0/6 (-)	0/5 (-)	1/4 (-)	0/5 (-)
Total	3/19 (15.8%)	8/19 (42.1%)	7/21 (33.3%)	0/19 (0%)
2015–2019				
No injuries	2/5 (-)	5/5 (-)	4/5 (-)	0/5 (-)
Trauma	0/0 (-)	0/0 (-)	0/0 (-)	0/0 (-)
Disease	0/3 (-)	2/3 (-)	1/3 (-)	0/3 (-)
Total	0/8 (-)	7/8 (-)	5/8 (-)	0/8 (-)
Green turtle				
2010–2014				
No injuries	4/6 (-)	6/6 (-)	0/6 (-)	0/6 (-)
Trauma	4/23 (17.4%)	14/15 (93.3%)	1/11 (9.1%)	0/11 (0%)
Disease	1/3 (-)	2/2 (-)	0/2 (-)	0/2 (-)
Total	9/32 (28.1%)	22/23 (95.7%)	1/19 (5.3%)	0/19 (0%)
2015–2019				
No injuries	3/5 (-)	5/5 (-)	0/5 (-)	0/5 (-)
Trauma	5/7 (-)	7/7 (-)	0/7 (-)	0/7 (-)
Disease	0/3 (-)	1/3 (-)	0/3 (-)	0/3 (-)
Total	8/15 (53.3%)	13/15 (86.7%)	0/15 (0%)	0/15 (0%)

*Supplementary Table B-14. Biotoxin analysis for sea turtles that stranded in Alabama, Mississippi, and Louisiana during 2015–2019. Category refers to predominant stranding and necropsy observations, including A = no major abnormalities; B = traumatic injuries; C = health-related; D = unable to categorize; and IC = incidental capture by fisheries. Biotoxin analytical results are reported for brevetoxins (PbTx) and cyanobacterium (Cyano) toxins (adda microcystins and nodularins – MMPB) in ng/g based on detection by validated enzyme-linked immunosorbent assays (ELISA), liquid chromatography and mass spectrometry (LCMS), and liquid chromatography and tandem mass spectrometry (LC-MS/MS). Results that were below limits of detection (< LD), samples that were not analyzed (NA) are indicated. Microcystin ELISA LD is ~ 5 ng/g; MMPB method reporting limit = 4.8 ng/g.*Not detected by LCMS*

Identifier	Species	Stranding date	State	Category	Sample type	PbTxELISA	PbTxLCMS
ARC2015102701 /	Cc	10/27/2015	AL	C	Liver	< LD	NA
NMFS16-00118					Kidney	< LD	NA
					Gastric	14.6	NA
					Feces	29.3	NA
DAW2015122801 /	Cc	12/28/2015	AL	C	Liver	212.4	NA
NMFS16-00120					Kidney	70.5	NA
					Gastric	43.8	NA
					Feces	4048.0	NA
DMD2016030701 /	Lk	3/7/2016	AL	A	Liver	44.3	NA
NMFS16-00122					Kidney	18.0	NA
					Feces	<LD	NA
CCW2016031601 /	Lk	3/16/2016	AL	A	Liver	45.7	NA
NMFS16-00123					Gastric	47.4	NA
MOR2016033101 /	Lk	3/31/2016	AL	A	Liver	22.0	NA
NMFS16-00124					Kidney	14.8	NA
					Feces	9.6	NA
TNJ2015100701	Lk	10/72015	MS	A	Liver	28.9	NA
NMFS16-00228					Kidney	39.0	NA
					Gastric	60.2	NA
AMC2015120101	Lk	12/1/2015	MS	A	Liver	28.3	NA
NMFS16-00214					Kidney	16.4	NA
					Gastric	< LD	NA
					Feces	< LD	NA
WLH2016030801	Lk	3/8/2016	MS	A	Liver	35.1	NA
NMFS16-00229					Kidney	15.7	NA
					Gastric	< LD	NA
					Feces	12.2	NA

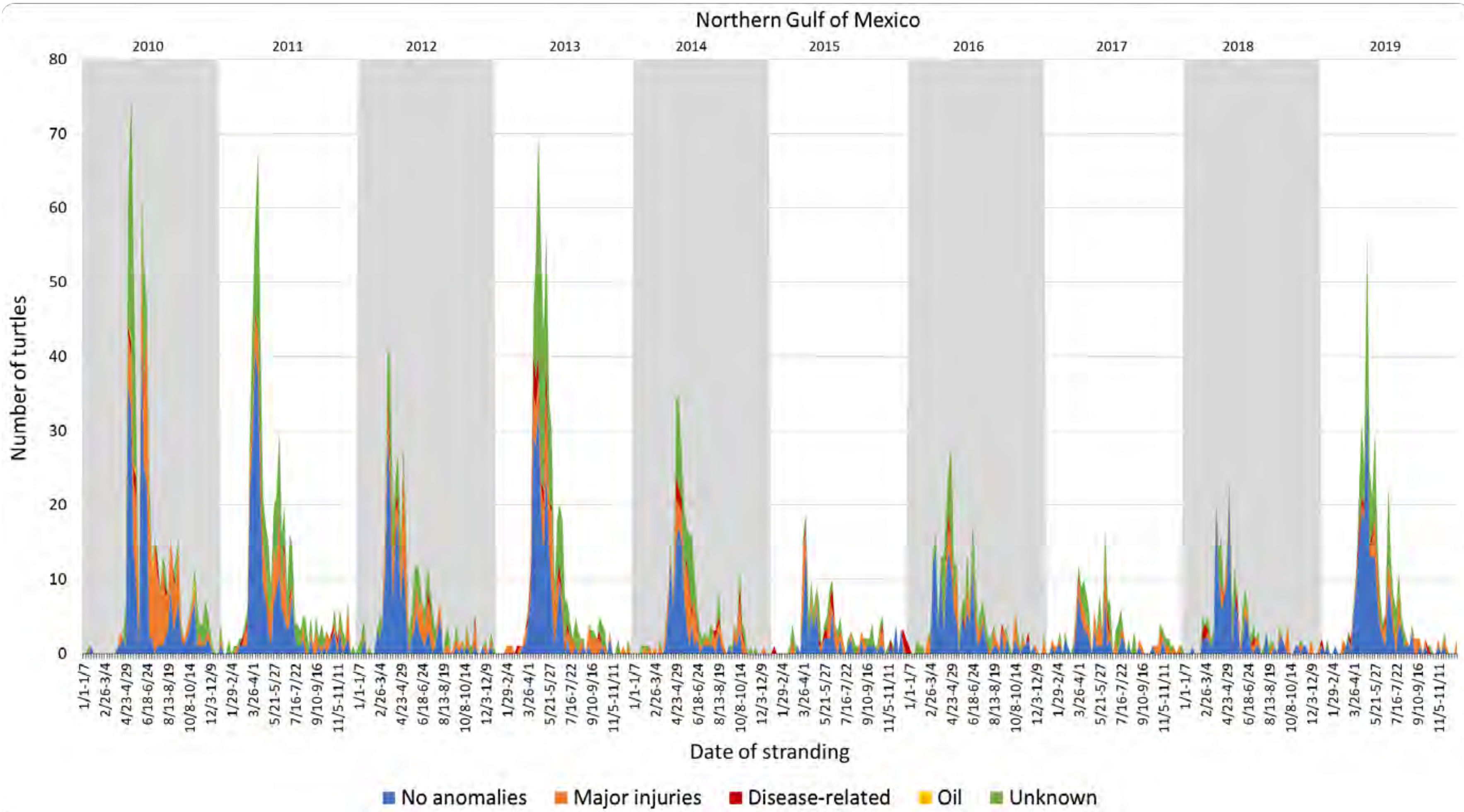
Supplementary Table B-14. Continued.

Identifier	Species	Stranding date	State	Category	Sample type	PbTx ELISA	PbTx LCMS
WLH2016030802 / NMFS16-00084	Lk	3/8/2016	MS	A	Liver	10	+
					Kidney	4”	< LD
					Gastric	5*	< LD
					Feces	30	+
AJH2016031202 / NMFS16-00081	Lk	3/12/2016	MS	A	Liver	61	+
					Kidney	22	+
					Gastric	86	+
					Feces	198	+
AJH2016031203 / NMFS16-00082	Lk	3/12/2016	MS	A	Liver	12*	< LD
					Kidney	4*	< LD
					Gastric	11	+
					Feces	22*	< LD
AMC2016031301 / NMFS16-00083	Lk	3/13/2016	MS	A	Liver	6	+
					Kidney	2	+
					Gastric	7	+
					Feces	84	+
AJH2016031701 / NMFS16-00201	Cc	3/17/2016	MS	A	Liver	22.0	NA
					Kidney	14.8	NA
					Feces	9.6	NA
AJH2016031802 / NMFS16-00203	Lk	3/18/2016	MS	A	Liver	11.3	NA
					Gastric	< LD	NA
					Feces	29.5	NA
AJH2016031901 / NMFS16-00204	Lk	3/19/2016	MS	A	Liver	11.4	NA
					Kidney	17.0	NA
					Gastric	< LD	NA
					Feces	39.1	NA
AMM2016033001 NMFS16-00225	Lk	3/30/2016	MS	A	Liver	< LD	NA
					Kidney	14.2	NA
					Gastric	13.0	NA
					Feces	50.8	NA
AMC2016033102 NMFS16-00216	Lk	3/31/2016	MS	A	Liver	11.1	NA
					Gastric	< LD	NA
					Feces	44.4	NA

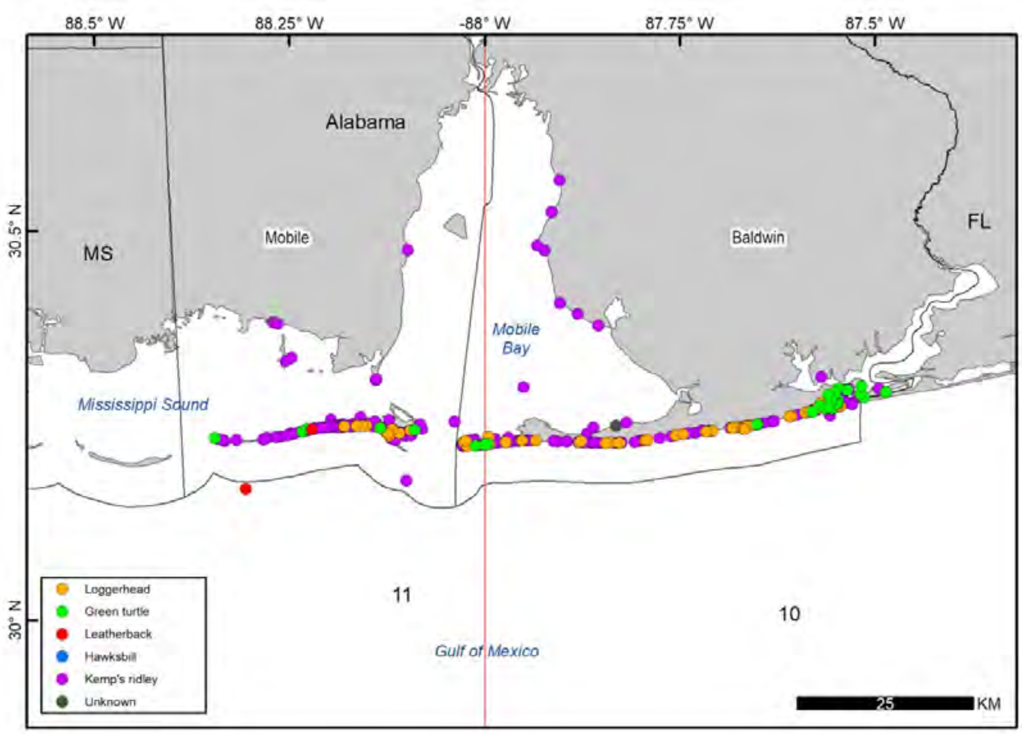
Supplementary Table B-14. Continued.

Identifier	Species	Stranding date	State	Category	Sample type	Cyano ELISA	Cyano MMPD
CDC2019061601 / GOMX19-00127	Lk	6/16/2019	MS	B1	Liver	5.3	< LD
					Kidney	18.0	< LD
					Gastric	9.7	< LD
					Feces	<LD	NA
CDC2019071501 / GOMX19-00129	Lk	7/15/2019	MS	D	Kidney	6.6	< LD
CRP2019063001 / GOMX19-00130	Cm	6/30/2019	MS	A	Brain	<LD	NA
					Liver	<LD	NA
					Kidney	<LD	NA
					Gastric	<LD	NA
					Feces	<LD	NA
CRP2019063002 / GOMX19-00131	Lk	6/30/2019	MS	A	Kidney	< LD	NA
MXC2019061801 / GOMX19-00132	Lk	6/18/2019	MS	B1	Kidney	8.4	< LD
					Gastric	7.0	< LD
EAS2019071301 / GOMX19-00133	Lk	7/13/2019	MS	A	Liver	< LD	NA
					Kidney	8.6	< LD
					Feces	< LD	NA

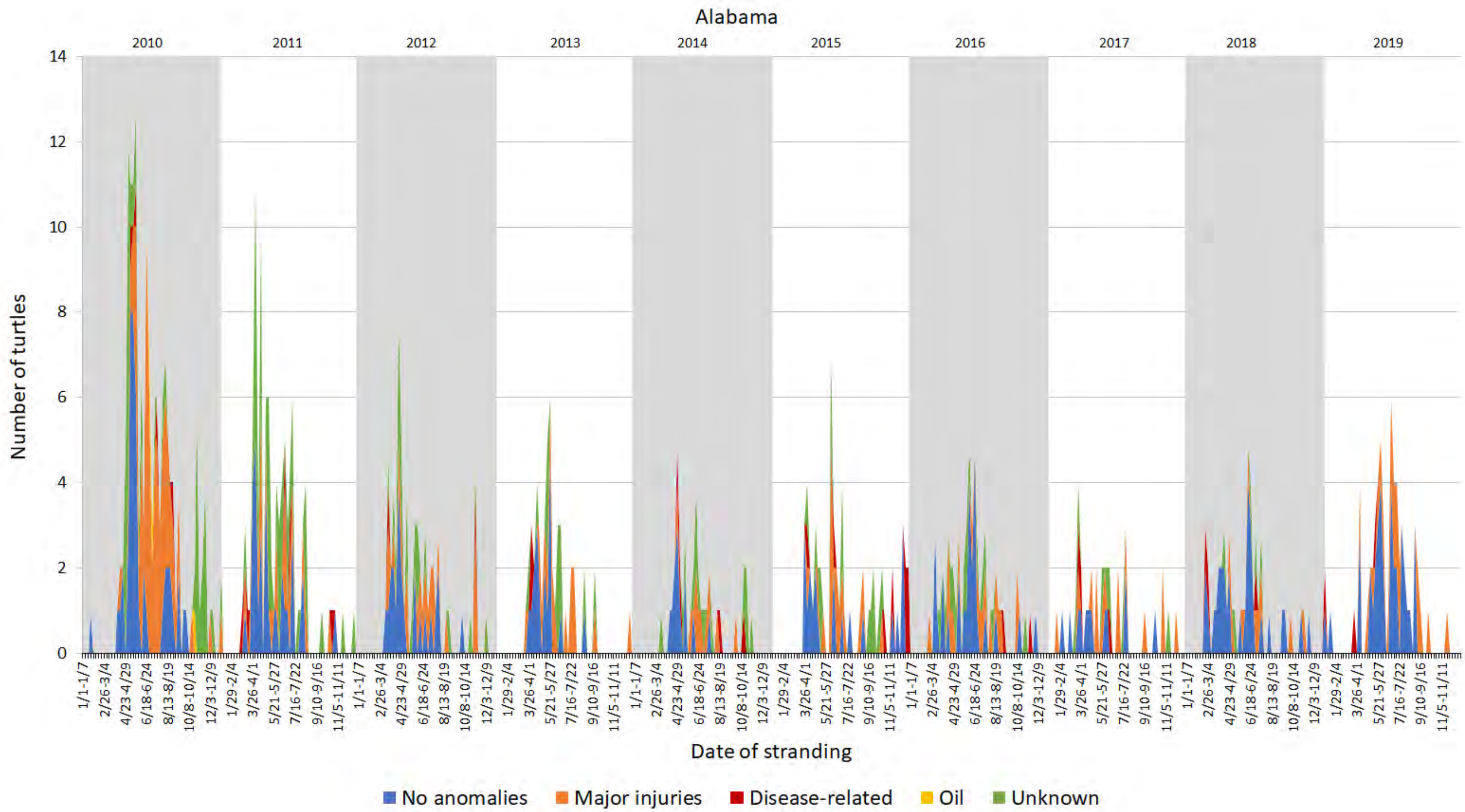
Appendix C. Supplemental Figures



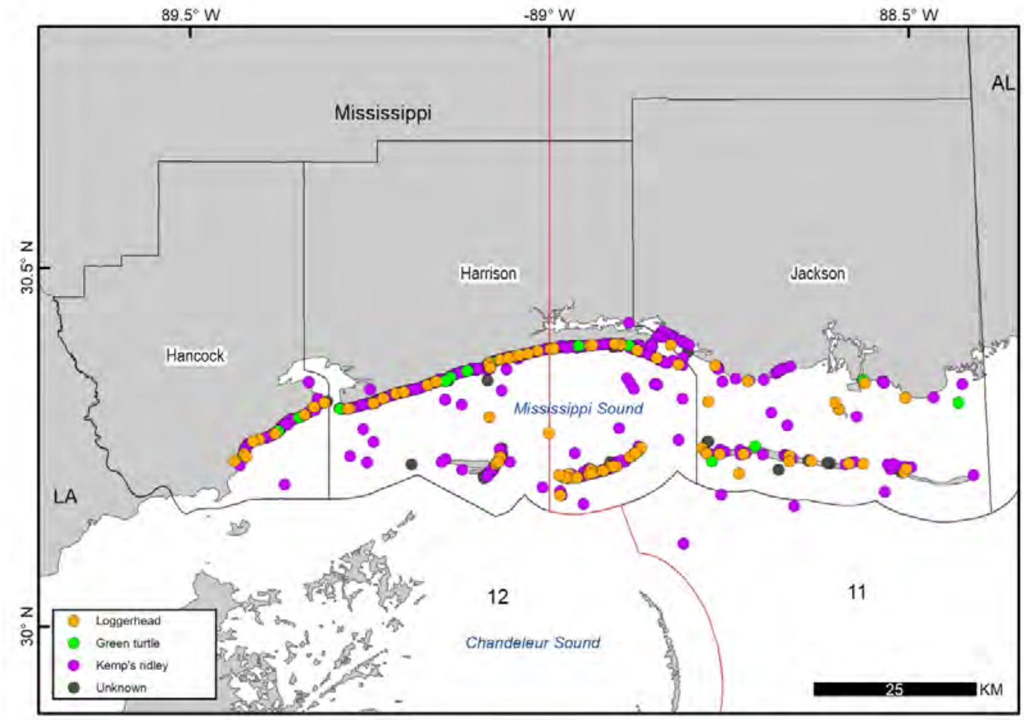
Supplementary Figure C-1. Categories of stranding and necropsy observations in the northern Gulf of Mexico are shown graphically by the week from 2010–2019.



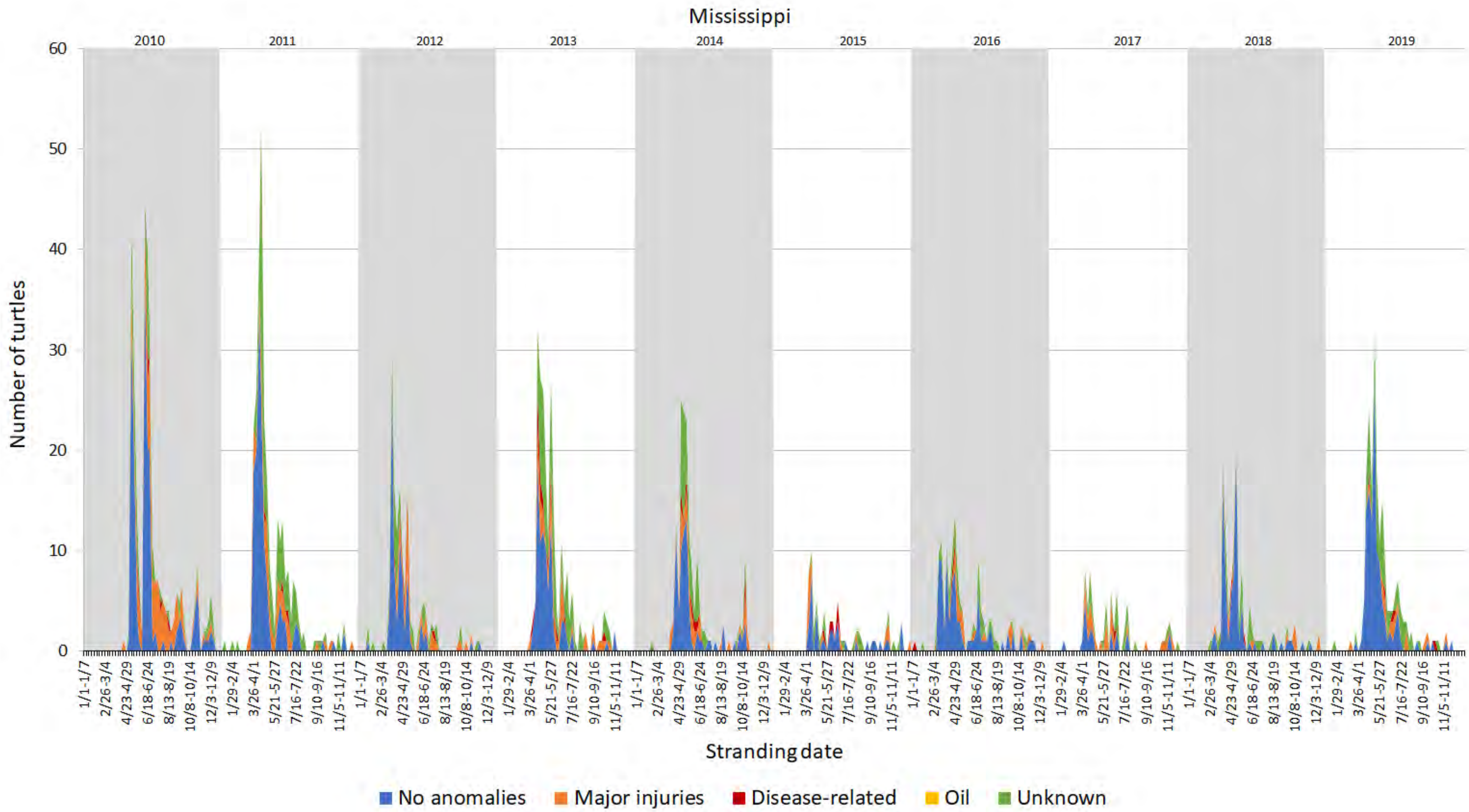
Supplementary Figure C-2. Locations of sea turtle strandings documented by the Alabama STSSN during 2015–2019.



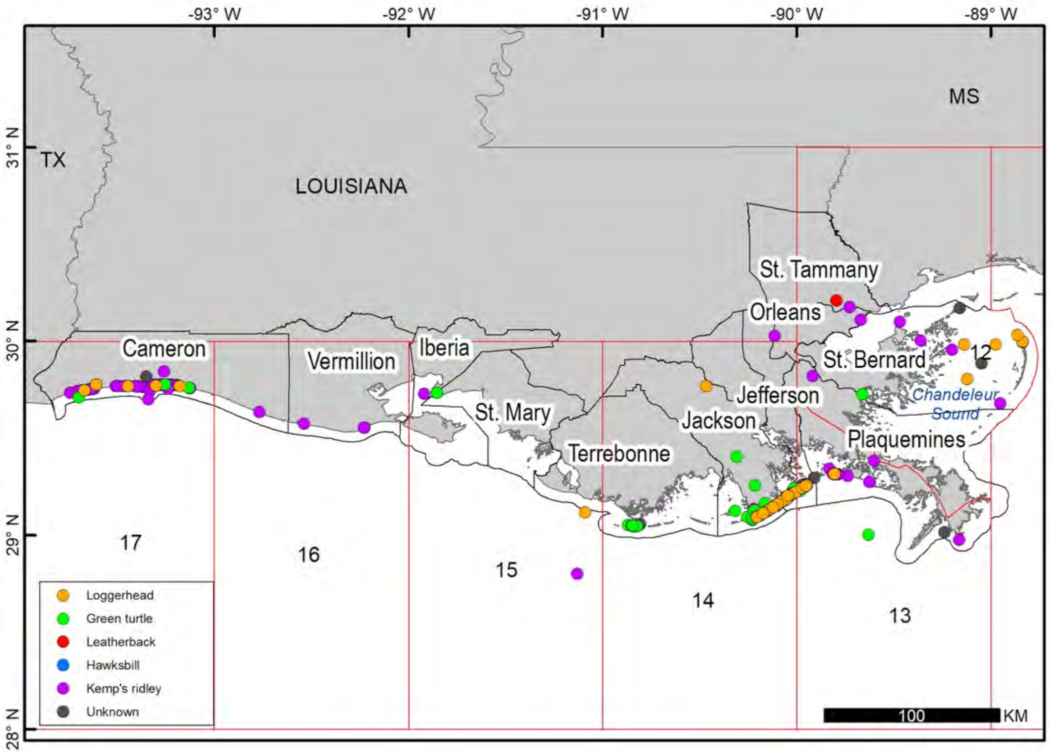
Supplementary Figure C-3. Categories of stranding and necropsy observations in Alabama are shown graphically by the week from 2010–2019.



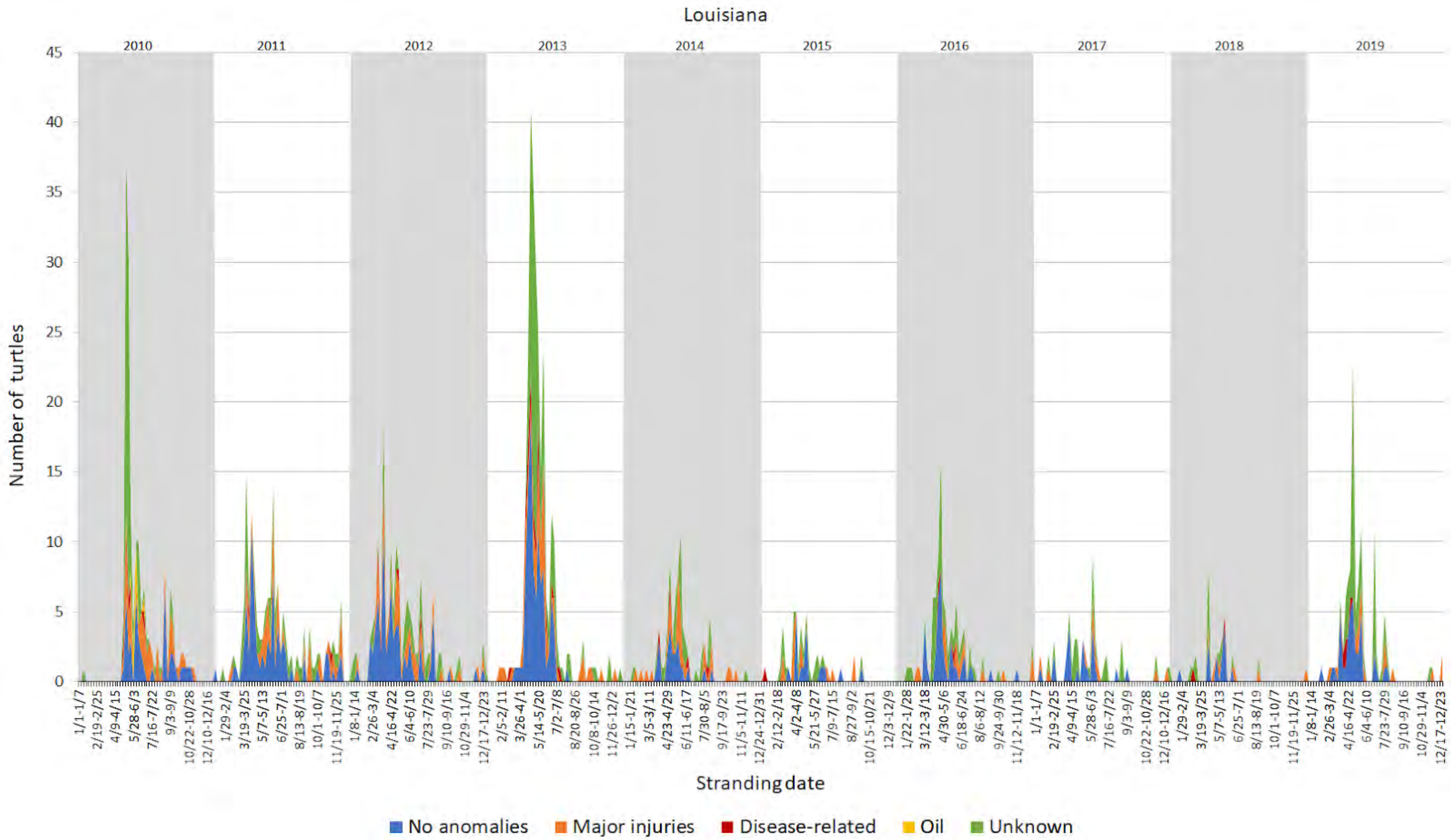
Supplementary Figure C-4. Locations of sea turtle strandings documented by the Mississippi STSSN during 2015–2019.



Supplementary Figure C-5. Categories of stranding and necropsy observations in Mississippi are shown graphically by the week from 2010–2019.



Supplementary Figure C-6. Locations of sea turtle strandings documented by the Louisiana STSSN during 2015–2019.



Supplementary Figure C-7. Categories of stranding and necropsy observations in Louisiana are shown graphically by the week from 2010–2019.