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PELAGIC NEONATE AND JUVENILE SEA TURTLES IN GULF AND ATLANTIC SURFACE WATERS OFF FLORIDA: DISTRIBUTION, DENSITIES, THREATS, HABITAT DESCRIPTIONS, AND BEHAVIOR

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PELAGIC NEONATE AND JUVENILE SEA TURTLES IN GULF AND ATLANTIC SURFACE WATERS OFF FLORIDA: DISTRIBUTION, DENSITIES, THREATS, HABITAT DESCRIPTIONS, AND BEHAVIOR

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INTRODUCTION

Florida beaches host the majority of loggerhead (*Caretta caretta*), green turtle (*Chelonia mydas*), and leatherback (*Dermochelys coriacea*) nesting in the United States, and most of this nesting occurs along Florida's central and southern Atlantic coast. Hatchlings from these Atlantic beaches enter the ocean, swim from land, and remain between the Florida peninsula and the Gulf Stream for a period of several days to several weeks (Witherington 2002). Important loggerhead nesting beaches are also located on the Gulf of Mexico in southwest Florida.

Loggerhead post-hatchlings are known to inhabit lines of surface convergence near the boundaries of major currents, in slicks (calm surfactant layers lining surface downwelling zones), and in Langmuir circulation cells (windrows) (Witherington 2002). Although green turtle post-hatchlings are found within convergence lines less frequently than expected from their proportion among all hatchlings leaving east Florida beaches, analysis of gut contents (FWC/FWRI unpublished data) suggests that neonate green turtles forage on surface organisms commonly associated with convergence lines. There are currently no empirical observations of foraging neonate leatherbacks.

In addition to post-hatchling turtles that have recently recruited from Florida nesting beaches, turtles from other nesting beaches are likely to inhabit convergence zones off Florida. These young oceanic-stage (epi-pelagic) turtles would be present off Florida if transported there within geostrophic currents like the Loop Current (Eastern Gulf of Mexico), the Florida Current (Straits of Florida and Atlantic), or combinations including surface advection from eddies and seasonal wind forcing. Some nesting beaches 'upstream' from waters off Florida include Tamaulipas, Mexico (Kemp's ridley, *Lepidochelys kempii*, nesting) and Yucatan, Mexico (loggerhead, green turtle, and hawksbill, *Eretmochelys imbricata*, nesting).

The extent to which lines of surface convergence and other epi-pelagic (open surface waters) habitat have been modified by pollution is an important conservation concern. Surface convergence sweeps neonate sea turtles together with the floating substrates they forage among, but these same forces also concentrate buoyant petroleum, plastics, and other anthropogenic debris. Preliminary work has shown that neonate sea turtles ingest this debris at a high frequency and incur mortality from its effects. Witherington and Hirama (2006) reported that of 83 post-hatchling loggerheads stranded in east Florida, 83.1% had ingested plastics and 33.7% had ingested tar.

In addition to the chronic threat of debris ingestion there is the potential for massive mortality from acute events such as oil spills, chemical spills, and ship-test explosions. Fisheries that operate at the productive fronts where neonate sea turtles live are also likely to take sea turtles. This take is especially likely for fisheries like *Sargassum* harvesting that collect habitat substrate. The need for information about abundance, distribution, and biology of newly recruited sea turtles and about threats to their survival has not been filled by any other research project in the Western Atlantic. The purpose of this study was to locate and describe areas of the Atlantic Ocean and Gulf of Mexico near Florida that serve as developmental habitat for oceanic-stage sea turtles including neonates newly recruited from Florida nesting beaches. Important elements of this assessment were to quantify threats and gather life-history information. As part of our assessment of threats, we attempted to measure rates of plastics and tar ingestion in both wild-captured and stranded neonate sea turtles.

This report provides descriptions and analyses for information on neonate sea turtles collected at sea between 2005 and 2008, and recovered as strandings between 2004 and 2007. We report on gut contents from turtles stranded between 1996 and 2007.

STUDY AREAS

Study areas included locations in the Atlantic Ocean and Gulf of Mexico off Florida (Fig. 1). There were seven locations described by the ports closest to the offshore areas studied: St Augustine, Cape Canaveral/Sebastian Inlet, Key West, Marco Island, Sarasota, Apalachicola, and Pensacola. The areas were defined by the extent of locations where epi-pelagic habitat was found. Habitat included floating *Sargassum* algae, seagrasses, and other drift material. Patches of floating material that were smaller than 1 m^2 and not aligned in linear rows were generally not surveyed. Patches of habitat were believed to be at areas of surface convergence brought about at geostrophic current boundaries, centers of surface eddies, slicks (as from downwelling behind internal wave crests, and other sources), wind-generated rows (as from Langmuir circulation cells), and other lines of downwelling created by surface advection.

MATERIALS AND METHODS

We conducted searches for epi-pelagic habitat, ran transects, and captured turtles using an 8.2 m power catamaran vessel launched at eight ports along Florida's Atlantic and Gulf coasts. Searches were made for patches and lines of consolidated floating material (weed lines) that would indicate potential habitat for neonate sea turtles. Our work seasons were July through September during the years 2004—2008. Offshore trips were made during periods of calm sea state (Beaufort force 0—3) when weather conditions were suitable for locating weedlines (wind disperses the floating material).

Searches for habitat were made along courses extending out from each port approximately perpendicular to the coastline. Upon reaching an area where we expected to find habitat (e.g., near locations of previously found habitat or near oceanographic features correlated with previously found habitat) we would often deviate course right or left and continue along zigzag search paths. We used predictions of geostrophic currents from satellite-based altimeter data (measuring sea-surface height anomalies) to target searches for epi-pelagic habitat. These data were available in near real-time format at the site:

http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html

The geostrophic current features we targeted included areas of high local advective shear (where there were changes in current vectors along a spatial gradient), frontal occlusions, and associated frontal eddies.

When habitat was found, we began searching along transects that passed through the center of the floating material making up the habitat. Because the floating material was mostly linear, transects were also approximately linear. Occasionally, transects were along bent lines to accommodate windrows that existed as interrupted offset lines. We rarely encountered habitat that existed only as individual, nonlinear patches. Patches like this greater than 10 m across were searched along two parallel transects.

Search transects through habitat were timed. Vessel speed relative to surrounding water, bearing, and transect path over ground (from WAAS GPS) were recorded automatically, approximately every minute during transect searches. Distance over water was calculated for each transect using vessel speed and search time. During search transects the vessel always maintained a bearing away from the transect starting point so that no turtle within the habitat could be counted more than once (vessel speed during transects was approximately five times the swimming speed of the most active post-hatchling loggerheads observed, mean = 6.4 km/hr).

Data recorded for turtles observed along transects included time, behavior, distance from the closest floating object, identity of the closest floating object, and perpendicular distance from the transect line (vessel path at time of observation). Behaviors were divided between five categories containing 12 modal action patterns previously observed in neonate sea turtles:

1) Motionless

a. Motionless spread—turtles floating motionless with flippers held away from the body.

b. Motionless tuck—turtles floating motionless with the ventral surface of front flippers pressed flat against the lateral carapace, and with rear flippers overlapping posterior to tail.

2) Breath

a. Breath without dogpaddle—turtles at the surface with head raised (and on closest examination, with inflated buccal-pharyngeal region indicating breaths taken) but little other movement.

b. Dogpaddle—turtles at the surface with head raised (and on closest examination, with inflated buccal-pharyngeal region indicating breaths taken) and with alternating, circular movements of all flippers.

3) Slow swim

a. Undetermined surface movement—turtles floating with water movement indicating motion but with no observation of flippers.

b. Slow swim—turtles with sluggish movement of front flippers but with their carapace remaining above the water's surface.

c. Rear-flipper kick (RFK)—turtles with the ventral surface of front flippers pressed flat against the lateral carapace, and with rear flippers making repeated simultaneous swimming strokes. Their carapace remains above the water's surface.

4) Subsurface swim

a. Powerstroke—turtles beneath the water's surface swimming horizontally using front-flipper strokes. Swimming interrupted by breath and dogpaddle pattern every 5—30 seconds. This is the swimming pattern shown by hatchlings during their first hours after entering the sea after leaving the nesting beach.

b. Dive—turtles beneath the water's surface swimming vertically using front-flipper strokes. Dives were observed to last up to several minutes and appeared to extend down to 10 m.

5) Feeding in or manipulating *Sargassum*

a. Feeding—turtles with various swimming or crawling strokes that were attempting to bite objects in front of them.

b. Crawling—turtles crawling on floating material with an alternating flipper movements similar to the gait used by hatchlings on the beach.

c. Parting with front flippers—turtles using their front flippers to move, part, separate, or manipulate floating material, typically *Sargassum.*

Behavior determinations were made at the instant we observed each turtle. Turtles believed to have been responding to the presence of the vessel or observers were categorized as such and not used in analyses.

We approximated each turtle's distance from the closest floating object in the categories of touching, near (within 1 m), and distant (outside 1 m). Identity of the closest floating object was given simple descriptions such as *Sargassum*, seagrass leaf, seagrass rhizome, plastic, etc. Perpendicular distance from the transect line was estimated by comparing or extrapolating distances from a graduated pole (the pole supporting our capture dipnet) that was four meters long.

A subsample of observed turtles was captured using a long-handled (4-m) dip net. Information recorded for captured turtles included health condition, injuries, straight carapace length (nuchal notch to longest pygal tip, SCL), weight, and evidence of plastic and tar ingestion from mouth examinations.

To gather additional information on the behavior of juvenile Kemp's ridleys, we captured four of these turtles and tracked them during overnight periods. Tracking was facilitated by the attachment of a sonic pinger (Sonotronics AST-05), which also logged time and depth. AST-05 instruments were fitted to turtles with a harness made of weak latex straps (breaking strength 2 kg new) secured around the carapace just anterior to the widest point. The harness held the AST-05 tightly to the turtle's plastron and bore a small foam float that made the combination neutrally buoyant (total weight = 50 g). The combination harness was adjusted to be hydrodynamic and have low potential for fouling on *Sargassum* or debris. Deterioration of the thin, latex straps would release the harness if the turtle could not be recaptured. Turtles were captured and released within 20 minutes at the *Sargassum* patch marking the location where they were originally observed (all turtles were captured from *Sargassum* patches).

We approximated the locations of the tracked turtle by recording signal strength and direction of the pinger through a directional hydrophone (DH-4) and receiver (USR-96). Locations were logged approximately every 20 minutes with the tracking vessels WAAS GPS for "close" signal strengths (estimated distance within 300 m from the turtle). "Close" distances correlated with strong sonic signals that were minimally directional (isotropic) and were verified by periodic triangulation of points.

The AST-05 recorded depths at 6-second intervals with a resolution of 3 cm. When the tracking episode concluded the tracked ridley was located by the pinger and recaptured by dipnet. The time/depth data were downloaded from the AST-5 upon retrieval of the turtle.

We randomly selected 133 loggerheads and 87 green turtles from a group of post-hatchlings that had stranded on Florida's Atlantic coast between August and December 1996 to 2007. All strandings were associated with storm events such as tropical storms and hurricanes. These turtles were necropsied, and their gut contents fully examined for the presence of plastics and tar. In a sub-sample of 70 green turtles and in all 133 loggerheads, we recorded percent frequency of ingested items. To do this we identified gut-content material under a binocular dissecting scope to the lowest possible taxon. Synthetic material was categorized by material, shape, and color. In a separate, randomly selected sub-sample, gut contents from 94 loggerheads and 87 green turtles were evaluated for dry mass of synthetic and non-synthetic components. After items were identified in these sub-samples we separated synthetic material (e.g., plastics, tar) from non-synthetic material (plant and animal tissue) and dried each in a drying oven until a constant mass was measured (typically 24 hours). Dry mass of synthetic and non-synthetic items from each turtle was determined by weighing on a digital balance ($\pm$ 0.001 g).

A GIS database was created for oceanographic information within the spatial range of the search effort, habitat locations and turtle capture locations described in this report. Oceanographic information included surface circulation, sea-surface temperature, Gulf Stream boundaries, and drifter paths. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

RESULTS

We made 13 trips in 2005 (July—September), five trips in 2006 (July—August), six trips in 2007 (May—August), and 10 trips in 2008 (May—August) for a total of 34 offshore trips. We made trips from St Augustine, Cape Canaveral and Sebastian Inlet, Key West, Marco Island, Sarasota, Apalachicola, and Pensacola (Fig. 1).

Transect searches of varying length and duration were conducted at locations off each port location. Between 2005 and 2008, sums of transect distances (calculated from logged GPS tracks) were 40.29 km off St Augustine, 85.53 km off Cape Canaveral/Sebastian Inlet, 22.57 km off Key West, 51.33 km off Marco Island, 59.36 km off Sarasota, 153.49 km off Apalachicola, and 9.45 km off Pensacola.

We observed 258 turtles on transects within epi-pelagic habitat (Figs 2—7). Densities of turtles varied between the four study areas surveyed (Table 1). The highest densities of loggerheads occurred in Atlantic areas, and the highest densities of green turtles, hawksbills and Kemp's ridleys were in northern and southern Gulf areas.

Of the 258 turtles observed on transects within epi-pelagic habitat, 187 were loggerheads, 43 were green turtles, 22 were Kemp's ridleys, four were hawksbills, and two were not identified. All but one of the observed loggerheads was considered to be likely young of the year (YOY, <10 cm SCL). Thirteen of the 43 green turtles were YOY, none of the 22 Kemp's ridleys were YOY, and none of the four hawksbills were YOY (Table 2).

We approximated an effective transect width in order to calculate turtle density within the habitat surveyed. Perpendicular distances from transect line for both small, YOY turtles (Fig. 8), and larger juveniles (Fig. 9) showed decreasing frequency of observations with distance. Given our assessment of the floating habitat and the locations of turtles relative to floating material, we believe that the frequency of turtle observations was a function distance due to both detectability and habitat width. We used the methods of Ramsey and Scott (1981) to estimate effective transect width based on cumulative frequencies of perpendicular distances. This effective transect width was similar (3—4 m) for both small YOY turtles and larger juveniles. From estimated widths of linear habitat made during transects, we calculated mean habitat width to be 6.3 m (SD = 6.8 m, n = 34 measures). Given the closeness of these estimates, we used 3.5 m as a conservative transect strip width, which excluded observations of 22 juveniles (14 green turtles and eight Kemp's ridleys) and 36 YOY (all loggerheads) from density calculations (Table 1).

We conducted additional analyses to estimate turtle densities using DISTANCE modeling (Thomas et al. 2004) of turtle observations and their perpendicular distance from the transect. Because sample size (number of individual transects) and number of observations (turtles) did not allow a division between species and locations, we divided turtles between only three groupings: young of the year (YOY), juveniles, and all turtles.

The total number of individual transects for all epi-pelagic turtle observations was 228 and extended 422.02 km. Models were run on data sets truncated at 6 m from transect (turtles observed > 7 m from transect were excluded). For all models, we used Akaike's information criterion to establish goodness of fit.

DISTANCE modeling of truncated YOY turtle observations (n=185) best fit a hazard-rate (broad-shoulder) model with a cosine function. For this model the estimated number of YOY turtles per hectare within the habitat transected was 0.827 (95% CI = 0.318—2.152 turtles/ha).

DISTANCE modeling of truncated juvenile turtle observations (n=45) best fit a half-normal (narrow-shoulder) model with a cosine function. For this model the estimated number of juvenile turtles per hectare within the habitat transected was 0.144 (95% CI = 0.0613—0.338 turtles/ha).

DISTANCE modeling of all trucated turtle observations (n=230) best fit a hazard-rate (broad-shoulder) model with a cosine function. For this model the estimated number of all turtles per hectare within the habitat transected was 0.957 (95% CI = 0.430—2.129 turtles/ha).

Behaviors of observed turtles indicated an association with floating material and low or moderate activity (Table 3). Most loggerheads were in the tuck behavior and within a meter of the closest floating material. Most green turtles were also within a meter of the closest floating material, but were most commonly feeding near or crawling upon the material. Most ridleys were swimming slowly within a meter of floating material, and the hawksbills were either in a tuck or using their front flippers to part the floating material, in both cases within a meter of it.

We captured and collected additional data on 188 loggerheads, 22 green turtles, 10 Kemp's ridleys, and four hawksbills (Table 2). All captured loggerheads were believed to be YOY. Of 22 captured green turtles, eight were YOY and 14 were larger juveniles. All hawksbills and Kemp's ridleys observed or captured were juveniles larger than YOY. SCL estimates of turtles not captured were made with the help of close-proximity size comparisons of turtles missed by the capture dipnet and the dipnet itself (later measured).

We used spatial comparisons of data and observations, mesoscale and smaller, to detect commonalities that would describe epi-pelagic sea turtle habitat (Figs. 10—40). Habitat locations and turtle observations in the Atlantic were correlated with sea-surface temperature indications and other assessments of the western Gulf Stream (Florida Current) front. Sea-surface height anomaly data indicated eddies at the western Gulf Stream boundary and at the northern extent of the Loop Current (Gulf of Mexico south of Apalachicola) that appeared to correspond to both habitat and observed turtle locations (Figs. 10—40).

We captured and released four juvenile Kemp's ridleys with sonic tracking and time/depth logging instruments (Figs. 41—44). Three turtles were recaptured so that data from the logging instrument could be retrieved. One turtle could not be recaptured.

Each tracked ridley showed minimal movement that was not obviously different from local surface geostrophic currents (Figs. 41—44). Dive depth data for the three recaptured turtles showed that they spent the majority of their time within 1 m of the water's surface (Figs. 45—47). Deepest dives were to no more than 30% of bottom depth and tended to flatten at this depth (i.e., turtles dove to a specific depth and remained there until their ascent). The longest dive durations were approximately 17 minutes. Many of the deepest and longest dives occurred at night, although each turtle showed a period of quiescence within a few hours of midnight. We observed that the deepest dives extended to the depth where we noted the location of the nocturnal scattering layer as recorded by the tracking vessel's sonar chart plotter.

A comparison of live-captured and dead-stranded loggerheads (Fig. 48) and green turtles (Fig. 49) revealed that stranded turtles used in this study were representative of the sizes of live YOY turtles found in the open Atlantic near Florida during the study season. A high proportion of dead stranded loggerhead (81%, n=181) and green turtle (83%, n=93) post-hatchlings had ingested plastics or tar. From the sizes of loggerheads and green turtles examined in this study, it appeared that larger/older post-hatchlings were more likely to have ingested synthetic debris (Figs. 50 & 51).

Dead loggerhead and green turtle post-hatchlings were found to have ingested a wide variety of synthetic material (Table 4, Figs. 52 & 53). Principal colors of synthetics were white and transparent. Most black synthetics were tar or covered with tar. In a random sub-sample of dead loggerhead post-hatchlings, synthetic debris made up 28.6% of the dry mass of their gut contents (Table 5). In a similar sub-sample from green turtles, this proportion was 46.1% (Table 5).

DISCUSSION

Characterizing Epi-pelagic Habitat for Sea Turtles

We observed post-hatchling and juvenile sea turtles in habitat composed of floating material that varied greatly in extent. By far, the most common floating material in this habitat was pelagic *Sargassum* species. The most common orientation of this floating material was in lines less than 10 m wide, although small clumps of *Sargassum* < 1 m^2 were often observed distant from any other floating material. Although it was difficult to quantify density and linearity of floating material, our qualitative assessments were that density of sea turtles increased proportionally with both density and linearity of *Sargassum*.

GIS analysis revealed that the most conspicuous oceanographic feature correlated with observations of epi-pelagic sea turtles was convergence at the western boundary of the Gulf Stream Front (Figs. 10—16). During the study period there was not a conspicuous presence of other features hypothesized to hold pelagic turtle habitat such as mesoscale eddies from the Loop Current. Instead, habitat in the Gulf of Mexico appeared to be correlated with many smaller scale features less likely to be visible in remotely sensed data. Observations of pelagic turtles were commonly made within dense, linear *Sargassum*, probably assembled by small-scale eddies and other types of downwelling such as from thermocline waves. In all locations, dense lines of *Sargassum* and other floating material were seen to break up into windrows (multiple, interrupted, parallel lines) when surface winds were greater than approximately 10 kts. Although it was not straightforward to determine whether habitat was a windrow or not, we had the greatest number of zero-observation transects within windrows. We feel that both floating material and sea turtles are less dense in separated windrows than in single lines surveyed during calm winds.

Turtle Densities within Epi-pelagic Habitat

Loggerhead post-hatchlings (YOY) were most densely distributed in habitat east of St Augustine, Cape Canaveral, and Sebastian Inlet near the western Gulf Stream (Table 1). These habitats are east and north (downstream) from the most productive nesting beaches in Florida, on the Central Atlantic coast (Meylan et al. 1995). On the Gulf coast, the most productive loggerhead beaches are in southwestern Florida, which is probably why loggerhead density west of Sarasota and Marco Island was high in comparison to waters off Apalachicola and Pensacola (Table 1).

All but one of the 14 green turtles observed off Cape Canaveral and Sebastian Inlet near the western Gulf Stream were YOY (Table 2). These post-hatchlings were observed in 2005 during a high nesting year for green turtles on Florida Beaches (FWC/FWRI unpublished data). It is not surprising that more green turtles than ever recorded in this area (Witherington 2002) were seen in this year. Surface-current patterns and turtle sizes suggest that the juvenile green turtles we observed in Gulf waters were not from Florida nesting beaches.

We believe that our observations and captures of epi-pelagic Kemp's ridleys are the first reported. Ridleys were observed south of Apalachicola and Pensacola, and west of Sarasota and Marco Island (Table 1). It is likely that epi-pelagic Kemp's ridleys inhabit a broad area of the eastern Gulf of Mexico in similar densities, especially north and east of the Loop Current. More sampling is needed in these areas.

Hawksbills were the least common turtles observed (n=4) and only juveniles larger than YOY were recorded. Hawksbills do not nest in significant numbers on Florida beaches and it is likely that these two came from other nesting areas "upstream."

Turtle Behavior

Both YOY and juvenile turtles showed behavior consistent with low or moderate activity and a close association with surface drift material (Table 3). Loggerheads were least active. Most were in a tuck, a behavior wherein turtles are quiescent except for head-up breathing every 5—30 seconds. In loggerheads observed for several minutes, tuck and rear-flipper kick (RFK) patterns often alternated. RFK was the second most common behavior in post-hatchling loggerheads. Ninety percent of observed loggerheads were within a meter of floating material, most commonly *Sargassum*. Green turtles were just as likely to be in close association with floating material but were more often in moderately active behaviors such as dogpaddle, feeding, and crawling (on *Sargassum*). Three green turtles were powerstroke swimming. Juvenile turtles larger than YOY of all species were at the surface when first observed and the majority of these were swimming slowly (or inactive).

The extended observations we made of juvenile Kemp's ridleys during overnight tracking episodes confirmed that they did not make extensive movements outside of Sargassum lines (Figs. 41—44) and that most of their time was spent near the surface (Figs. 45—47). Dive profile from these turtles showed occasional early evening and early morning deep dives to the upper level of the scattering layer as detected by sonar. No dives approached the sea bottom. We believe that these turtles are not likely to forage benthically in the locations where we observed them.

Plastics and Tar Ingestion

Dead stranded post-hatchlings offered an opportunity to completely sample gut contents for the presence of ingested plastics and tar. Our conclusions from the sample of post-hatchlings we examined were that ingestion of synthetic debris is high in these turtles (Tables 4 & 5), that probability of debris ingestion may increase with time (size/age of turtle, Figs. 50 & 51), and that white and transparent plastics were either favored or were most common in the habitat where these turtles forage (Figs. 52 & 53). Although we are not able to link the high levels of debris ingestion we observed with cause-of-death in this sample of turtles, it seems clear that the plastics and tar in their gut compromised many of them. Synthetic debris ingestion is no doubt an important conservation problem for epi-pelagic sea turtles.

LITERATURE CITED

Meylan, A., B. Schroeder, and A. Mosier. 1995. Sea turtle nesting activity in the State of Florida 1979-1992. Florida Marine Research Publications No. 52, 51 pp.

Ramsey, F.L., and J.M. Scott. 1981. Analysis Of Bird Survey Data Using A Modification Of Emlen's Method. Studies in Avian Biology 6:483—487.

Thomas, L., Laake, J.L., Strindberg, S., Marques, F.F.C., Buckland, S.T., Borchers, D.L., Anderson, D.R., Burnham, K.P., Hedley, S.L., Pollard, J.H. and Bishop, J.R.B. 2004. Distance 4.1. Release 2. Research Unit for Wildlife Population Assessment, University of St. Andrews, UK. http://www.ruwpa.st-and.ac.uk/distance/

Witherington, B. E. 2002. Ecology of neonate loggerhead turtles inhabiting lines of downwelling near a Gulf Stream front. Marine Biology (Berlin) 140:843—853.

Witherington, B. E., and S. Hirama. 2006. Pelagic plastic packs little loggerheads. In Pilcher, N. J. (compiler), Proceedings of the 23rd Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-536: 137—138.

Addendum to final report for NA06NMF4720031

Figures 1 through 53 are being sent on a CD to the NOAA Program Officer, Lisa Manning, for receipt on 27 October 2008. The file is too large to upload on GrantsOnline.

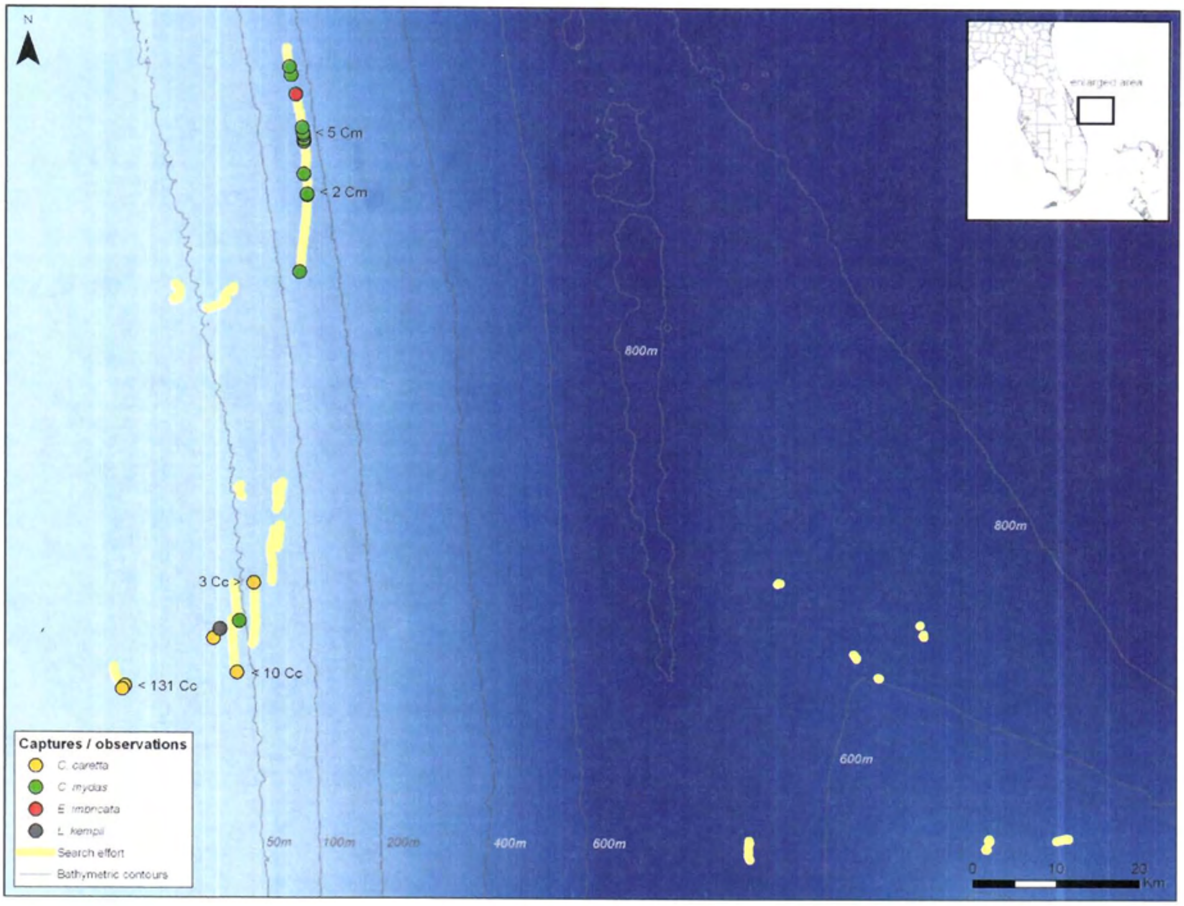

Figure 3. Search effort transect locations and sea turtle observations in epi-pelagic habitat in the Atlantic Ocean off Cape Canaveral and Sebastian Inlet, Florida: the Southern Atlantic Study Area.

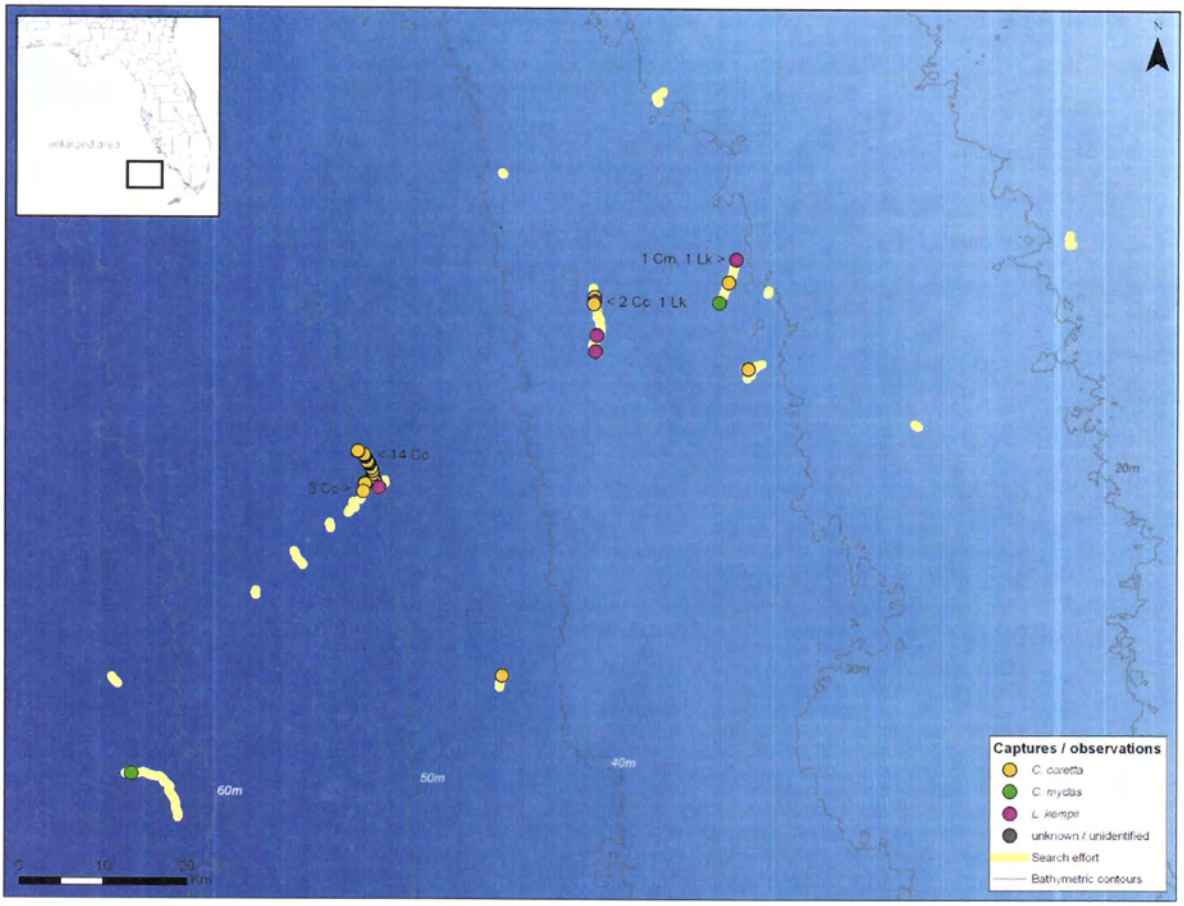

Figure 4. Search effort transect locations and sea turtle observations in epi-pelagic habitat in the Gulf of Mexico off Marco Island, Florida: the Southern Gulf Study Area.

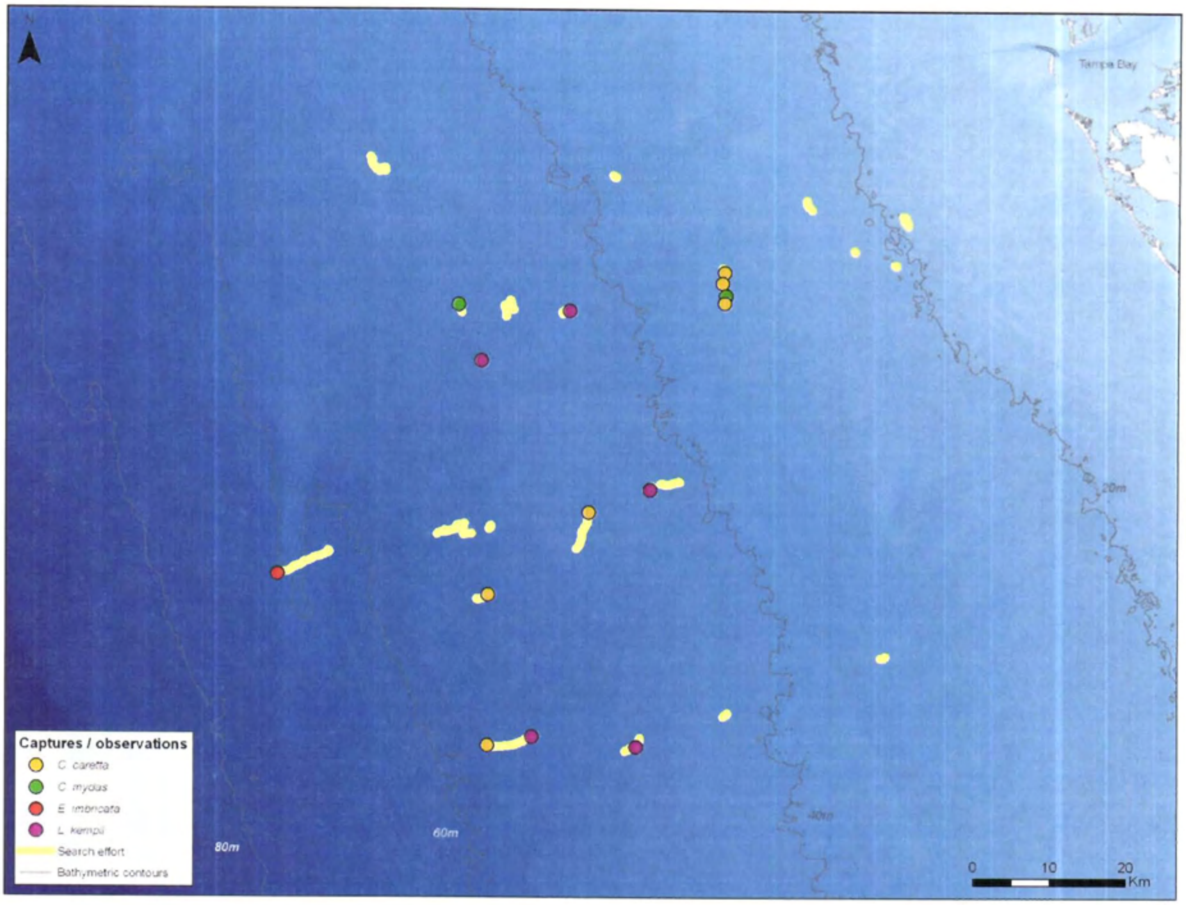

Figure 5. Search effort transect locations and sea turtle observations in epi-pelagic habitat in the Gulf of Mexico off Sarasota, Florida: the Southern Gulf Study Area.

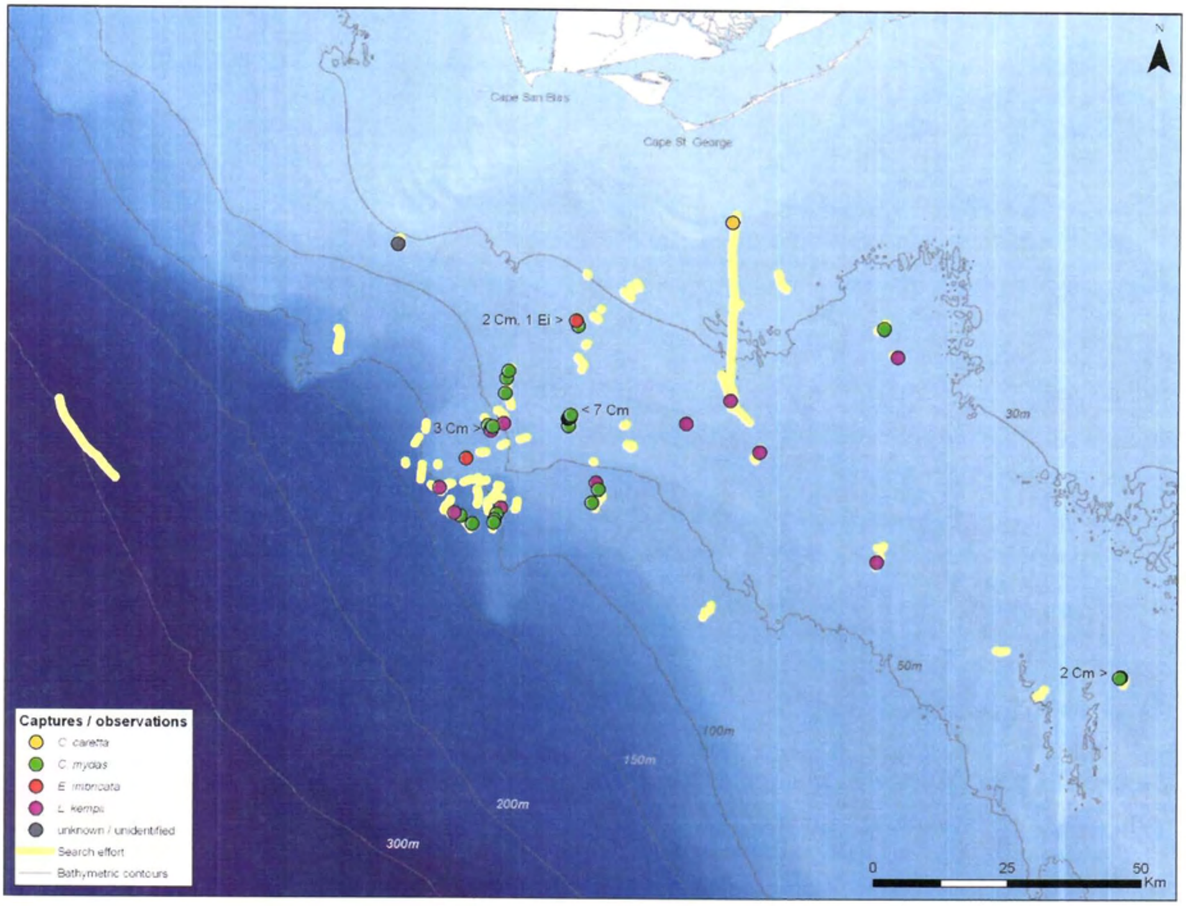

Figure 6. Search effort transect locations and sea turtle observations in epi-pelagic habitat in the Gulf of Mexico off Apalachicola, Florida: the Northern Gulf Study Area.

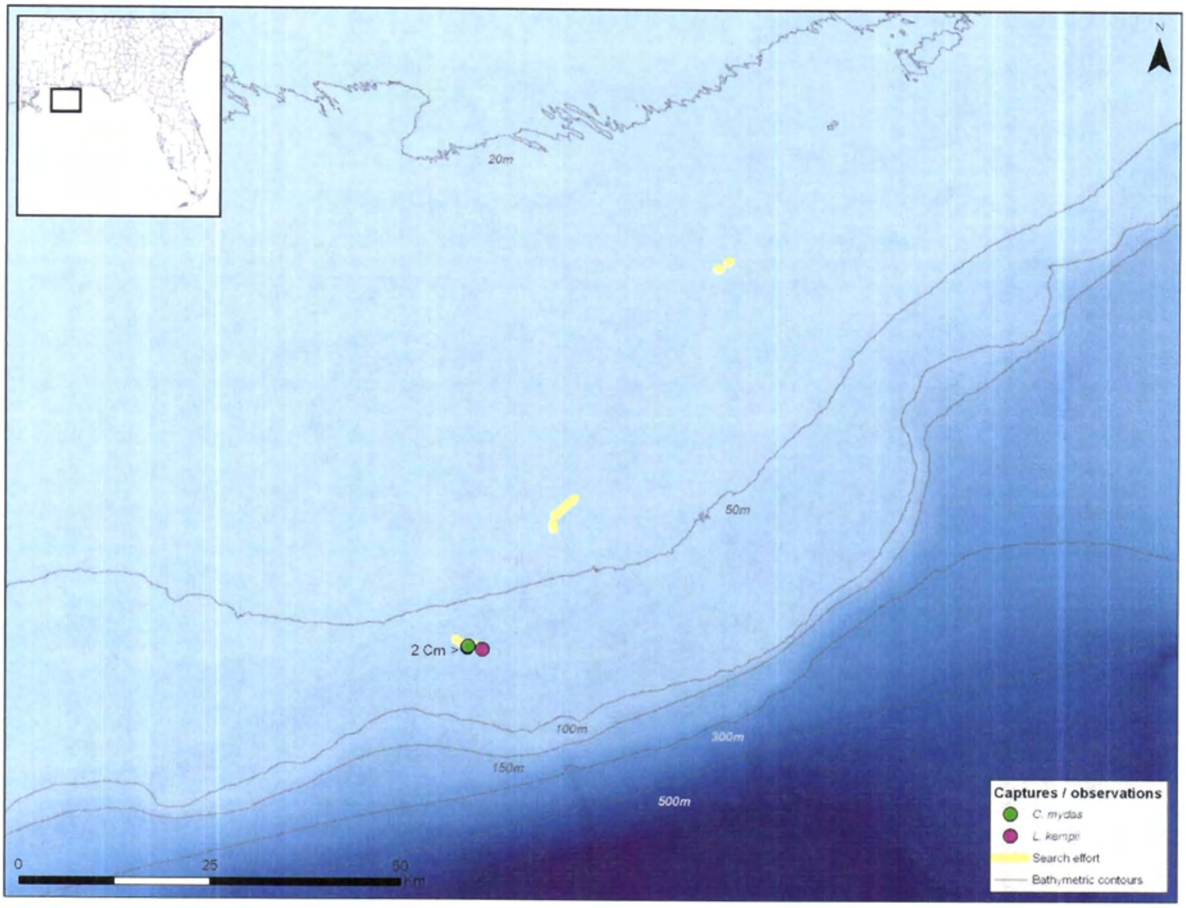

Figure 7. Search effort transect locations and sea turtle observations in epi-pelagic habitat in the Gulf of Mexico off Pensacola, Florida: the Northern Gulf Study Area.

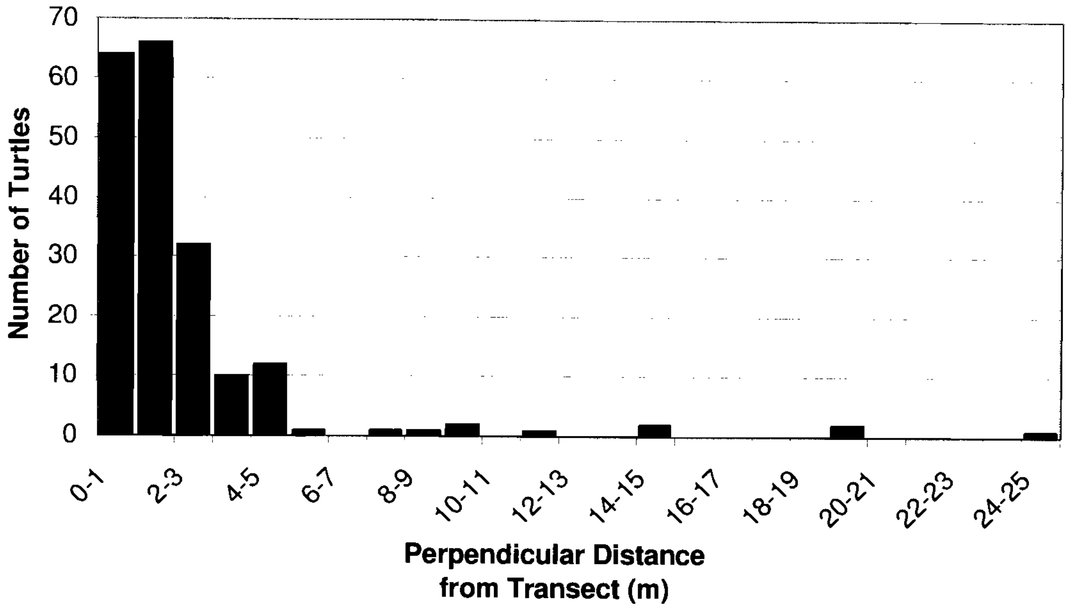

Figure 8. Distribution of 195 small, young of the year (<10 cm SCL) sea turtles (loggerhead, green turtle) by perpendicular distance they were observed from transect lines through epi-pelagic habitat off Florida, 2005—2008.

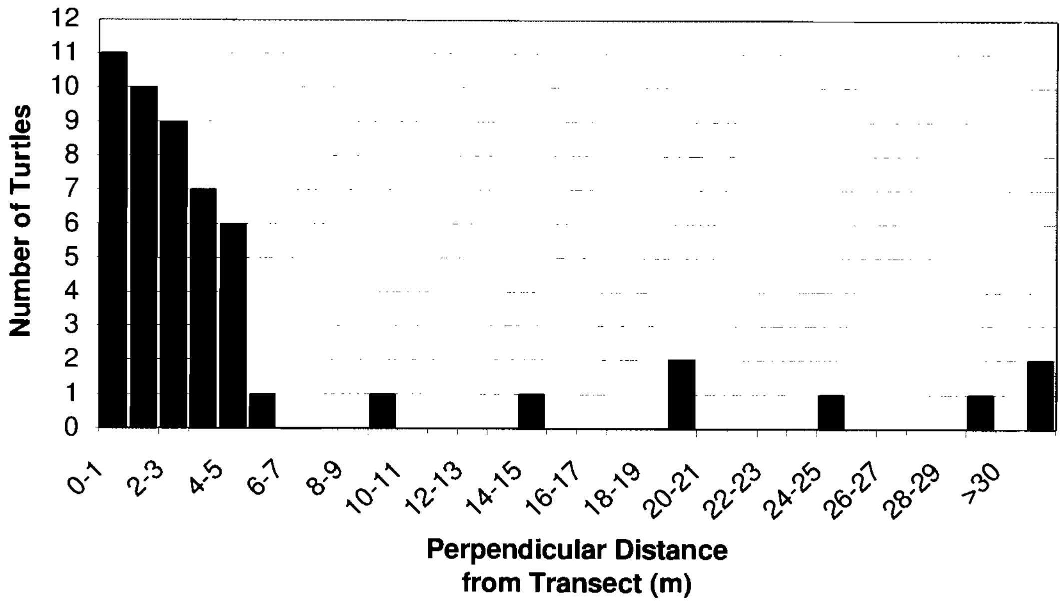

Figure 9. Distribution of 52 juvenile (>10 cm SCL) sea turtles (loggerhead, green turtle, hawksbill, Kemp's ridley) by perpendicular distance they were observed from transect lines through epi-pelagic habitat off Florida, 2005—2008.

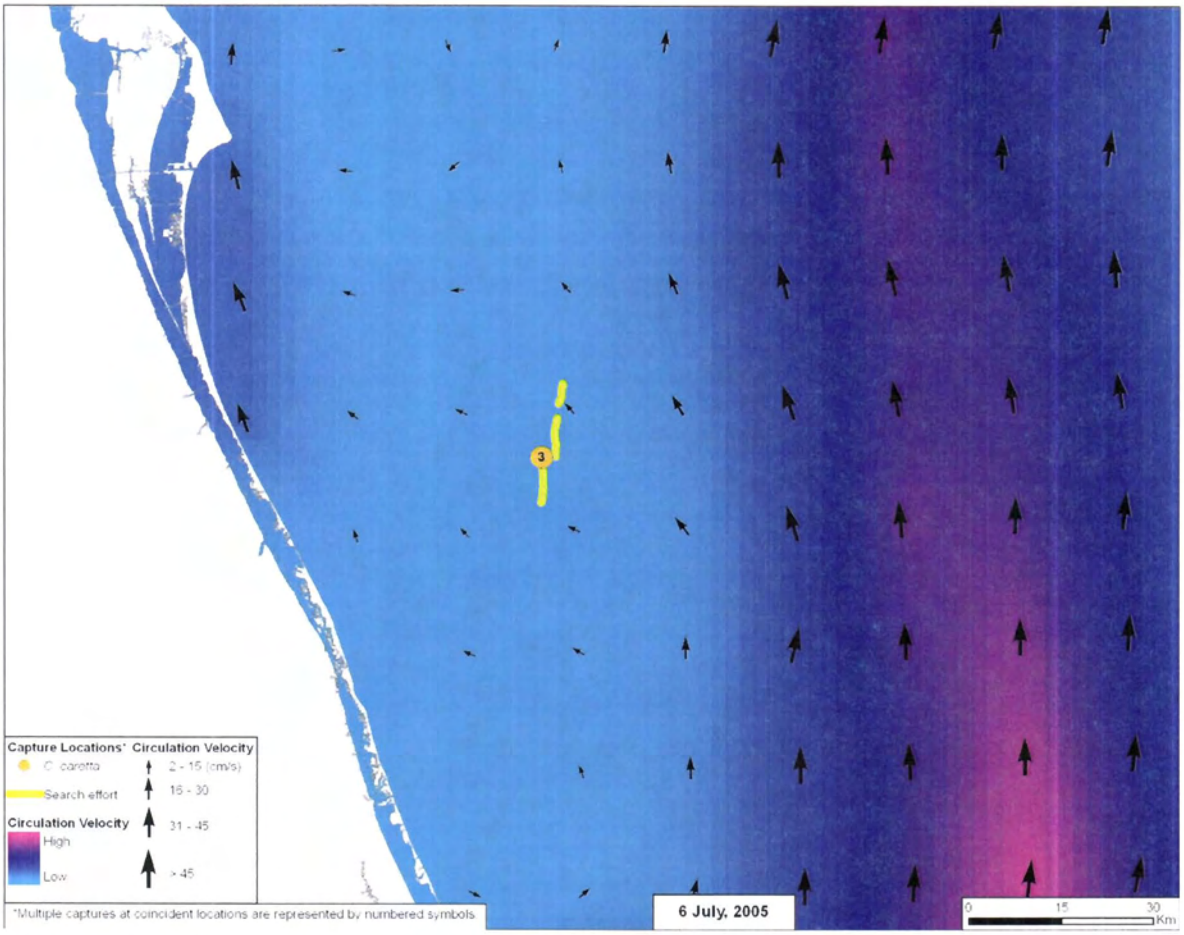

Figure 12. Sea turtle captures/observations and search effort made on 6 July 2005 in the Atlantic Ocean off Sebastian Inlet, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

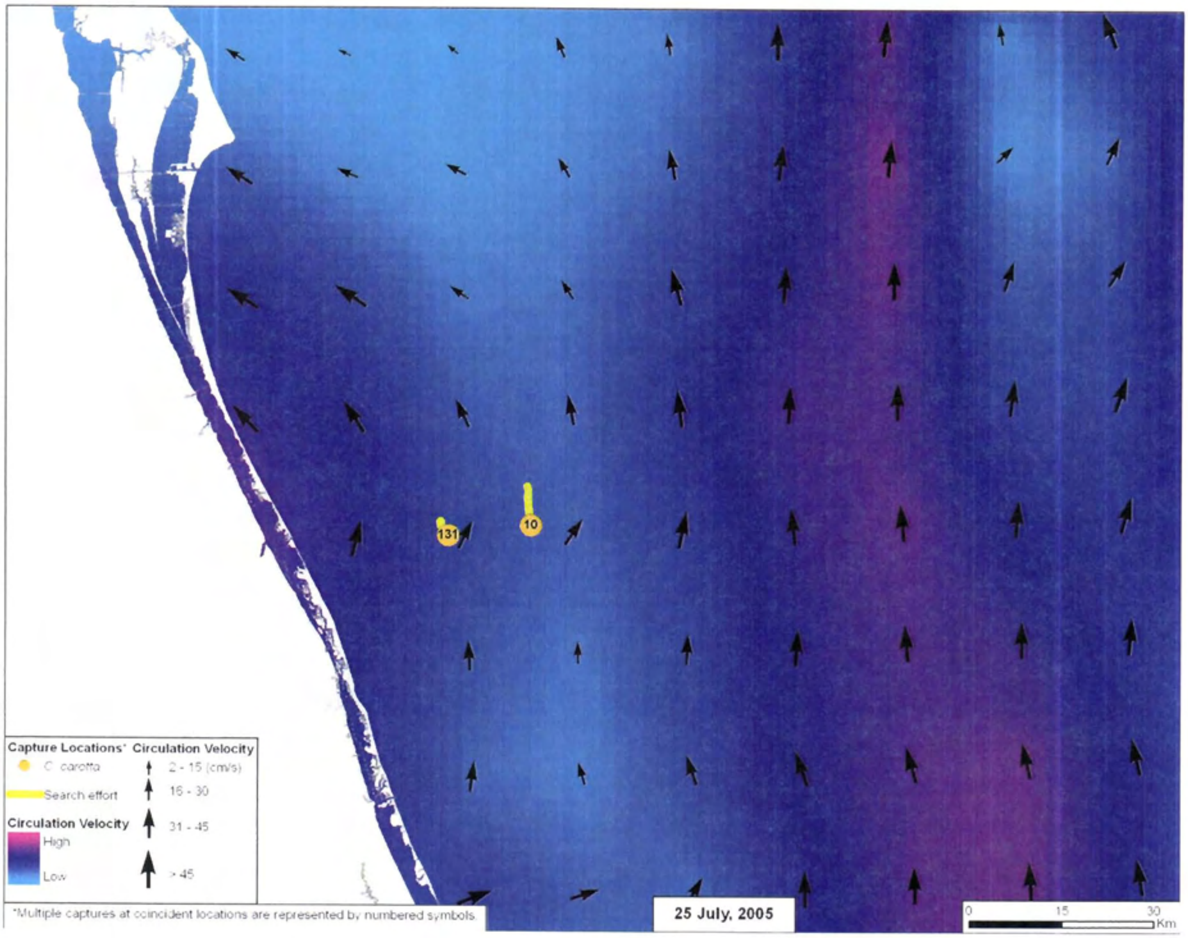

Figure 13. Sea turtle captures/observations and search effort made on 25 July 2005 in the Atlantic Ocean off Sebastian Inlet, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

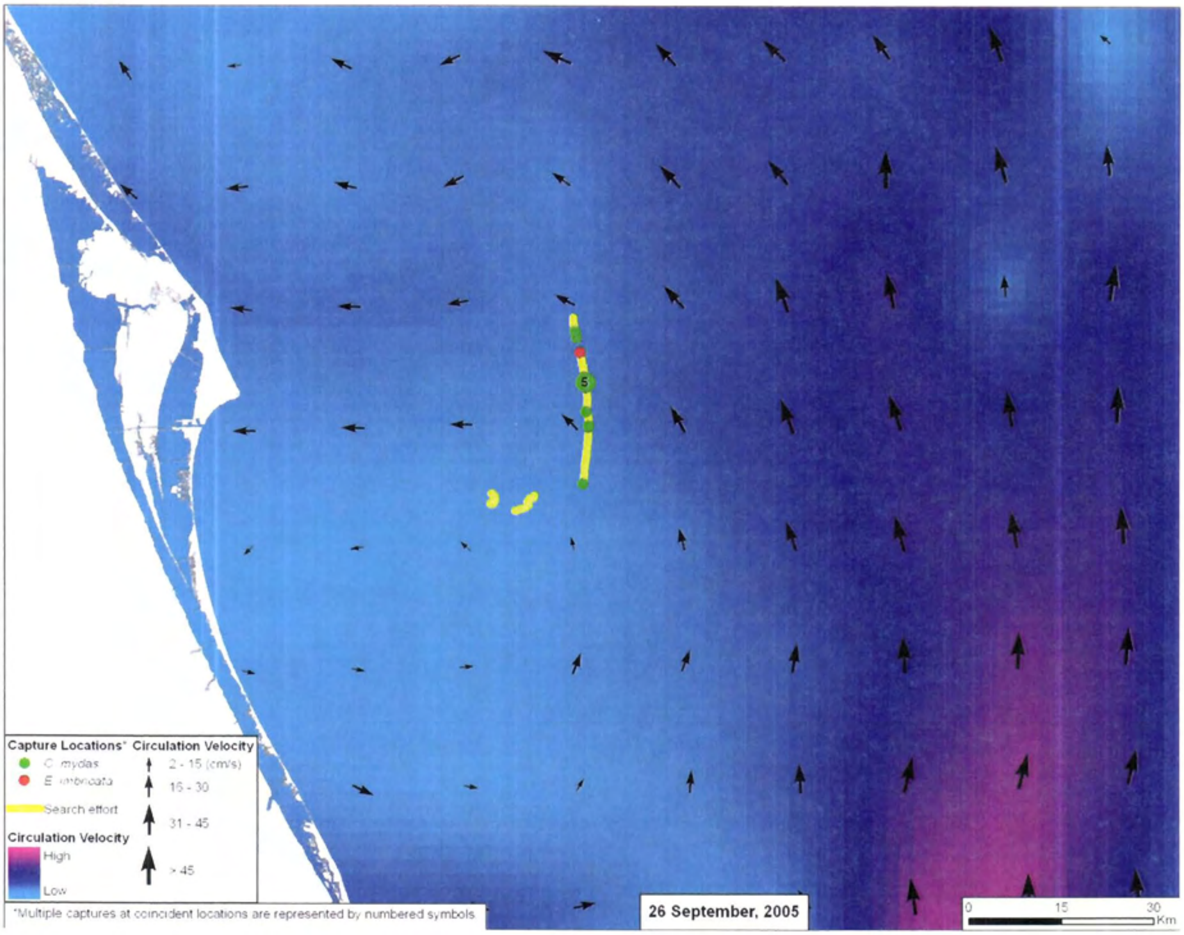

Figure 14. Sea turtle captures/observations and search effort made on 26 September 2005 in the Atlantic Ocean off Cape Canaveral, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

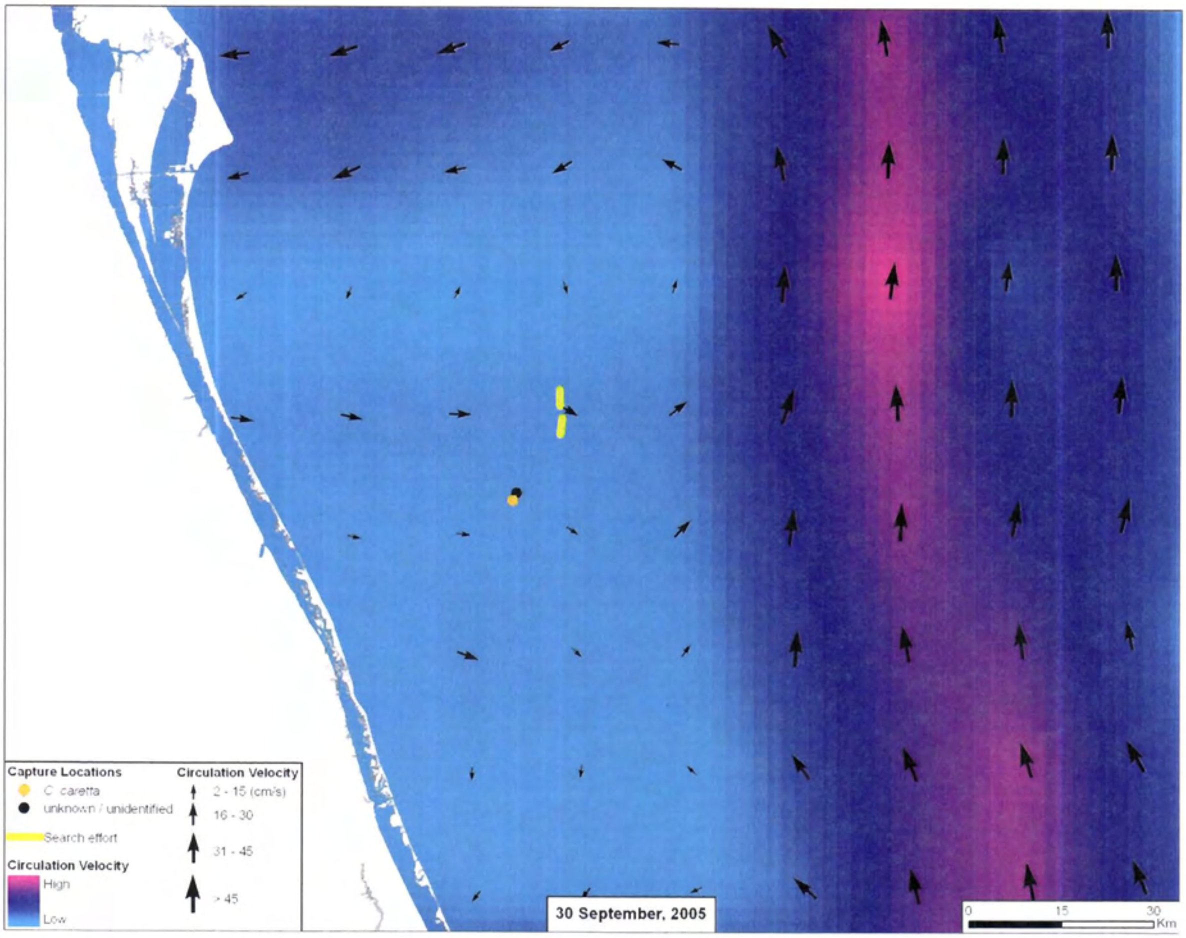

Figure 15. Sea turtle captures/observations and search effort made on 30 September 2005 in the Atlantic Ocean off Sebastian Inlet, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

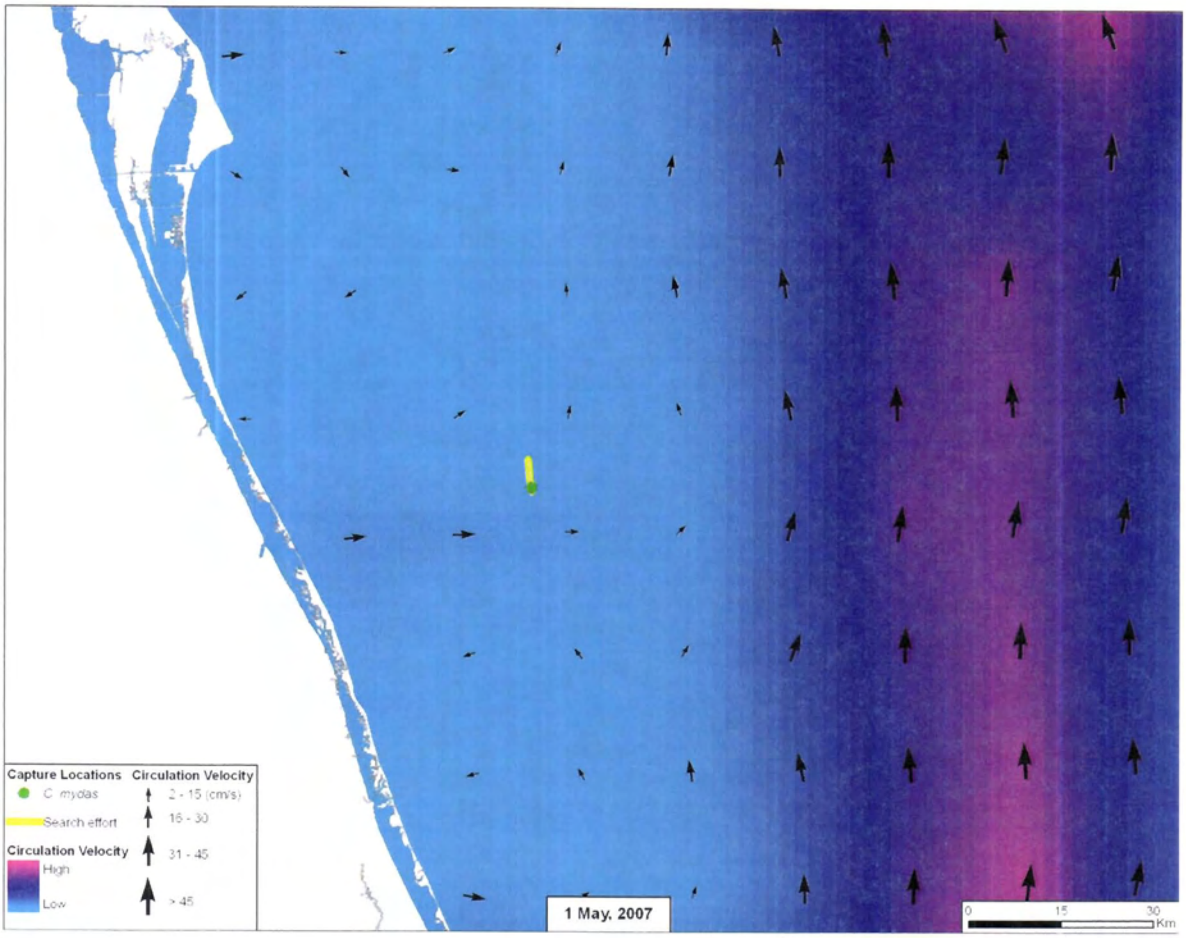

Figure 16. Sea turtle captures/observations and search effort made on 1 May 2007 in the Atlantic Ocean off Sebastian Inlet, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

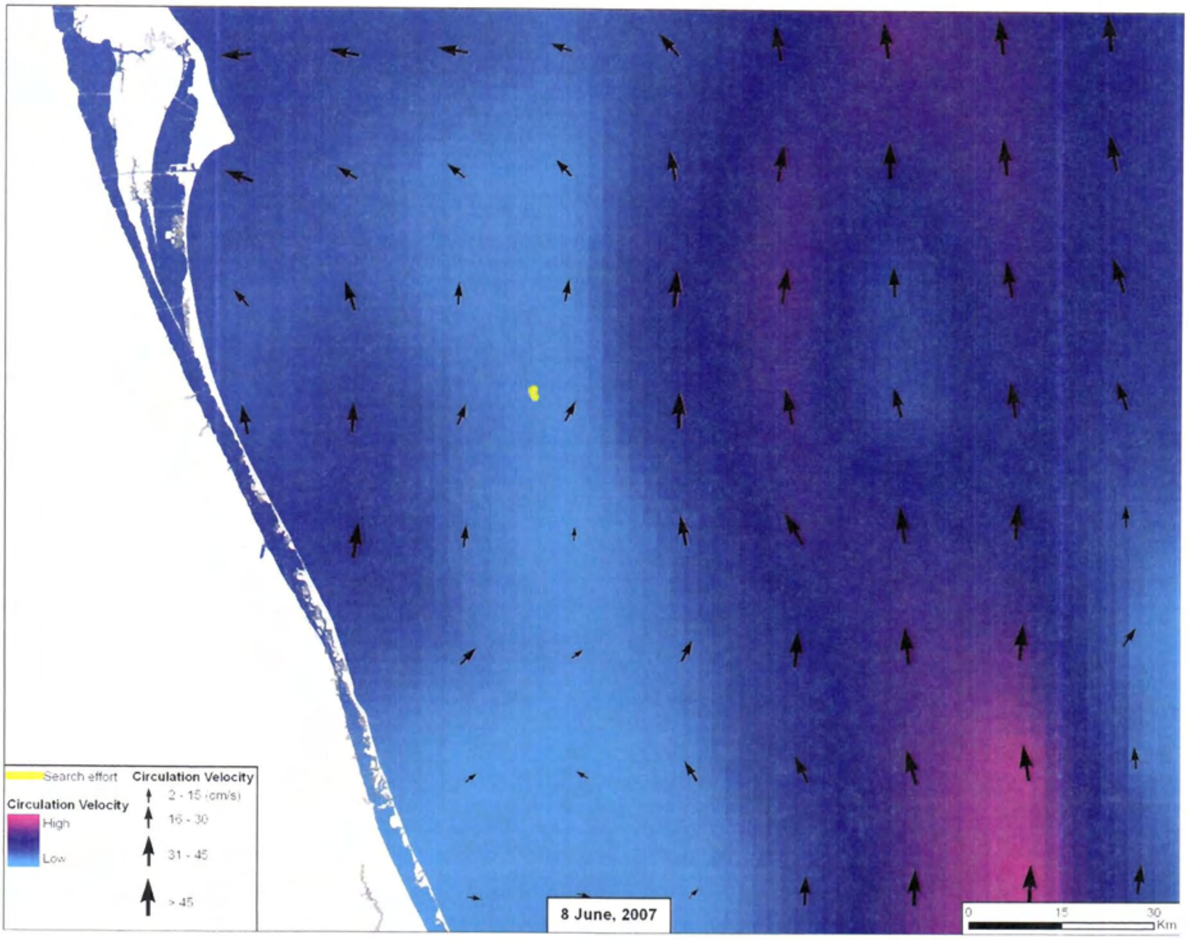

Figure 17. Sea turtle captures/observations and search effort made on 8 June 2007 in the Atlantic Ocean off Sebastian Inlet, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

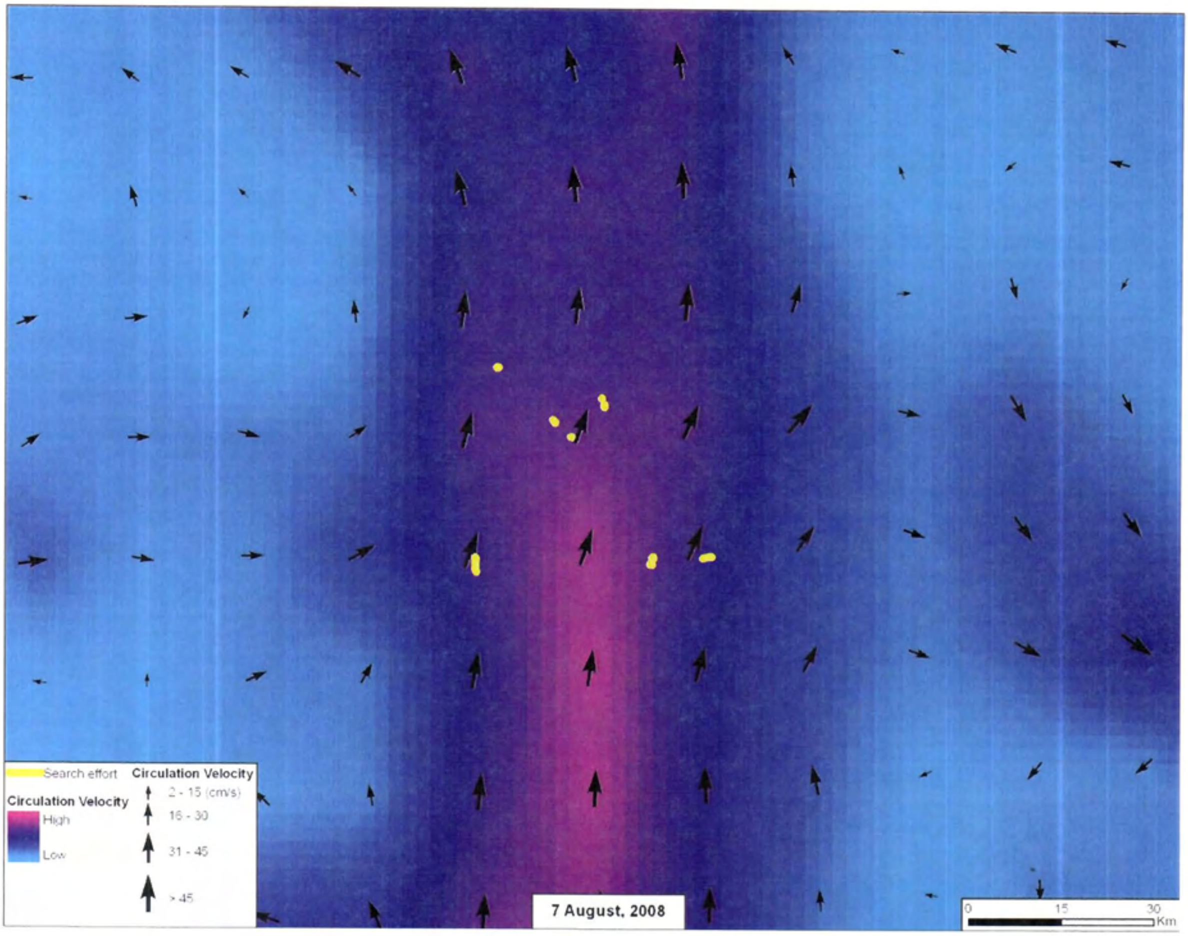

Figure 18. Sea turtle captures/observations and search effort made on 7 August 2008 in the Atlantic Ocean off Sebastian Inlet, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

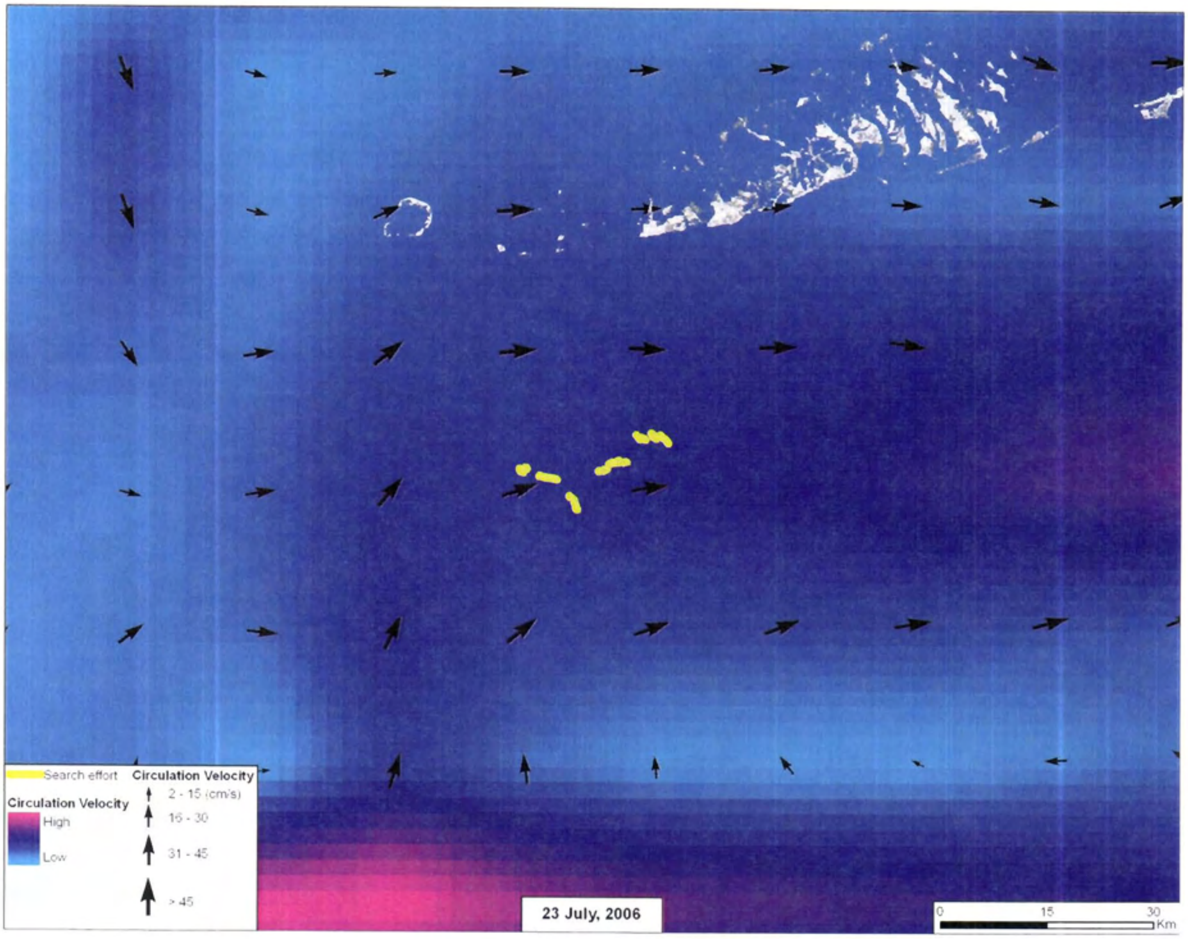

Figure 19. Sea turtle captures/observations and search effort made on 23 July 2006 in the Atlantic Ocean off Key West, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

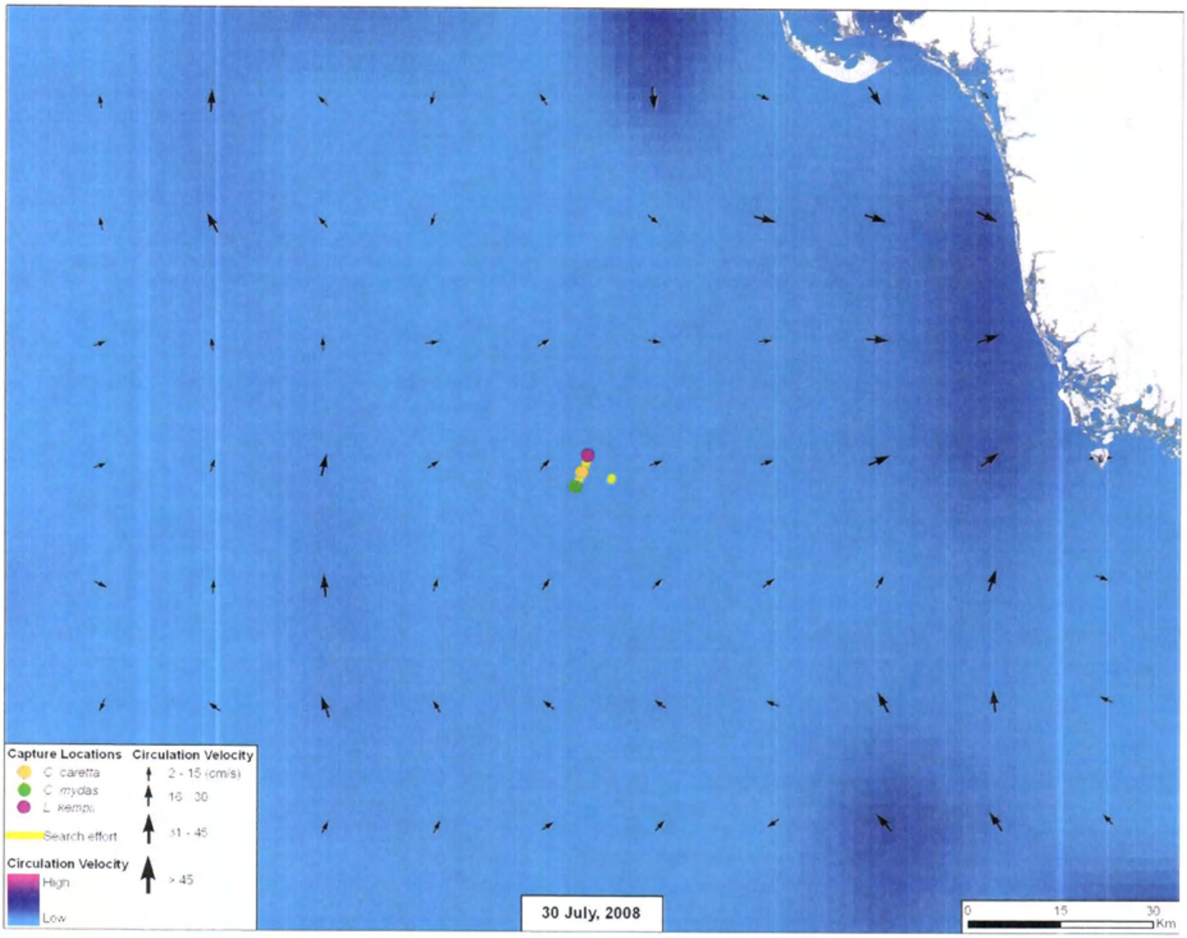

Figure 20. Sea turtle captures/observations and search effort made on 30 July 2008 in the Gulf of Mexico off Marco Island, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

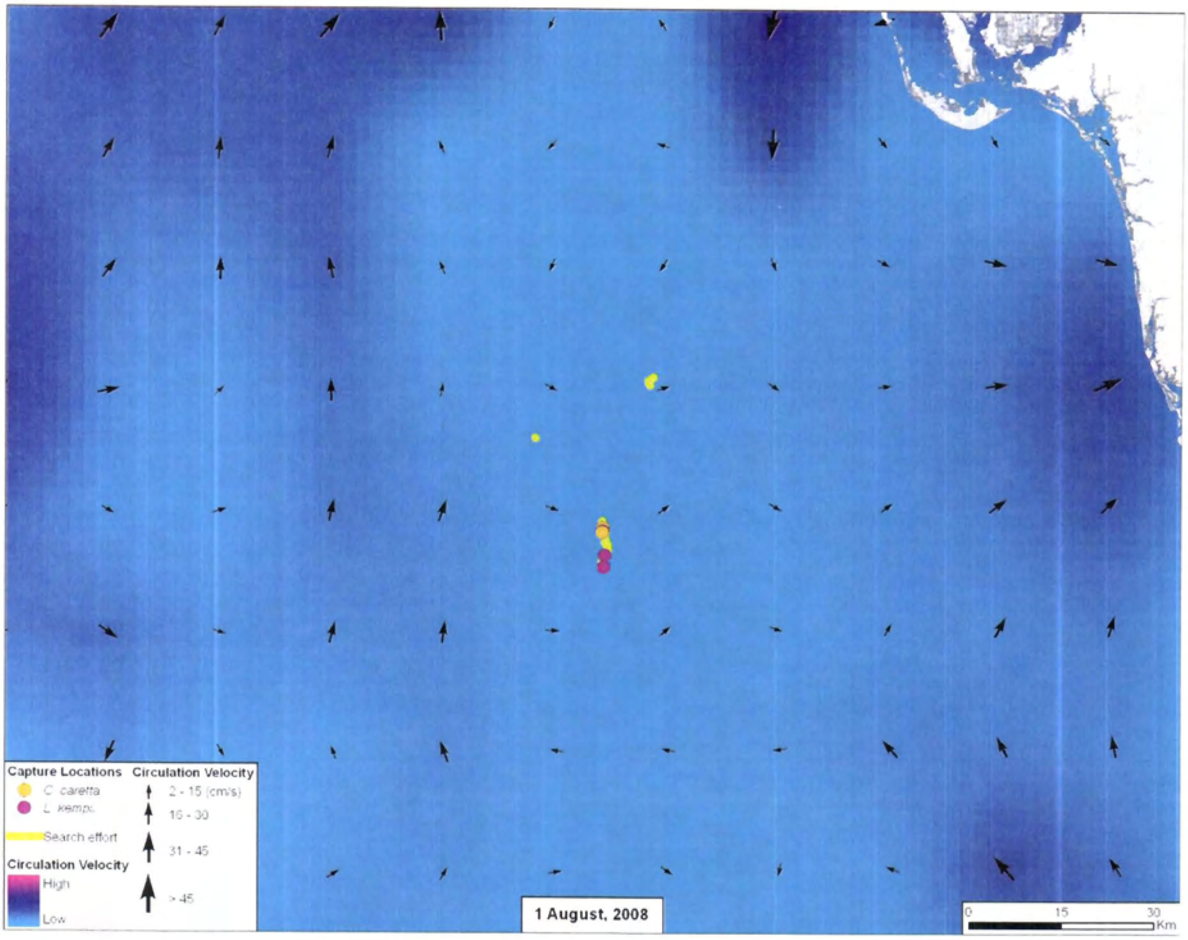

Figure 21. Sea turtle captures/observations and search effort made on 1 August 2008 in the Gulf of Mexico off Marco Island, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

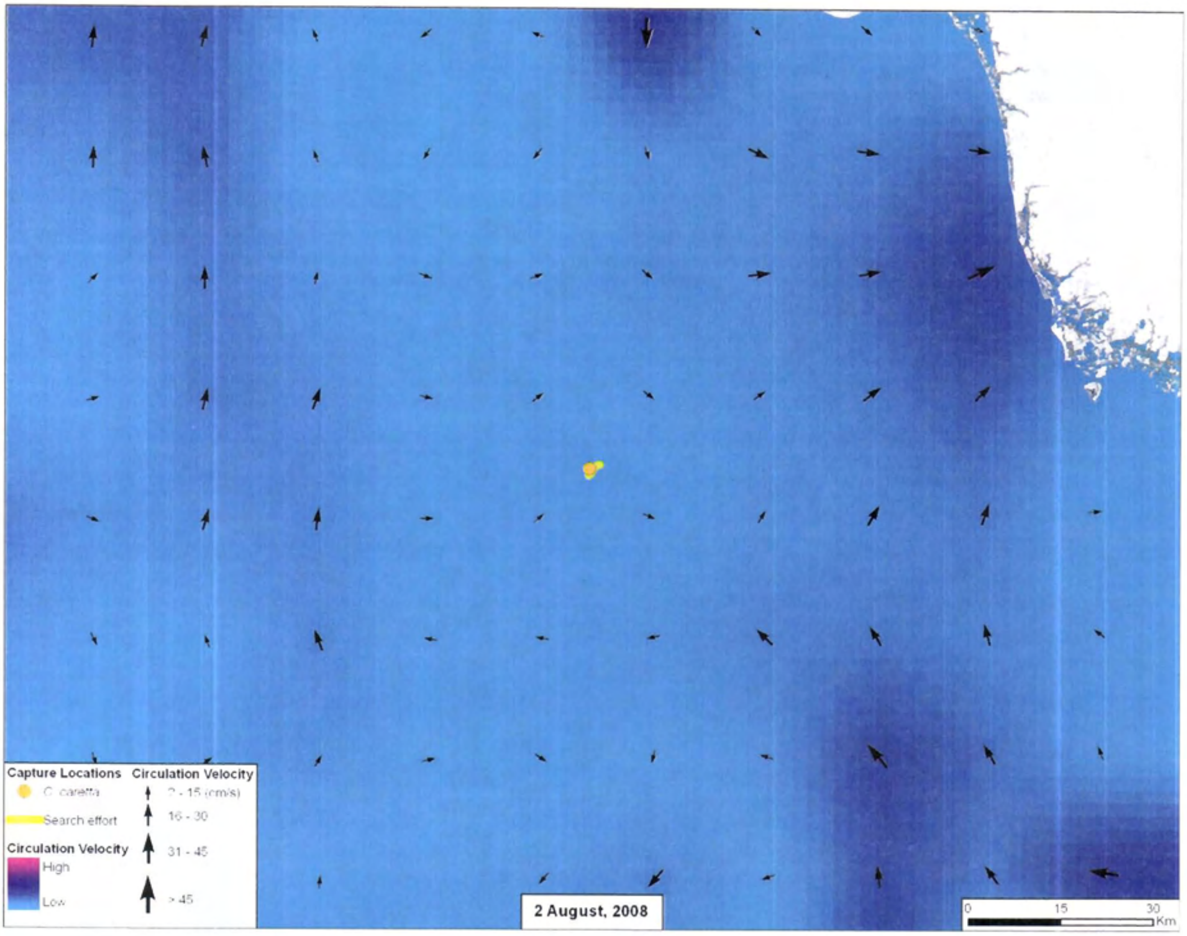

Figure 22. Sea turtle captures/observations and search effort made on 2 August 2008 in the Gulf of Mexico off Marco Island, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

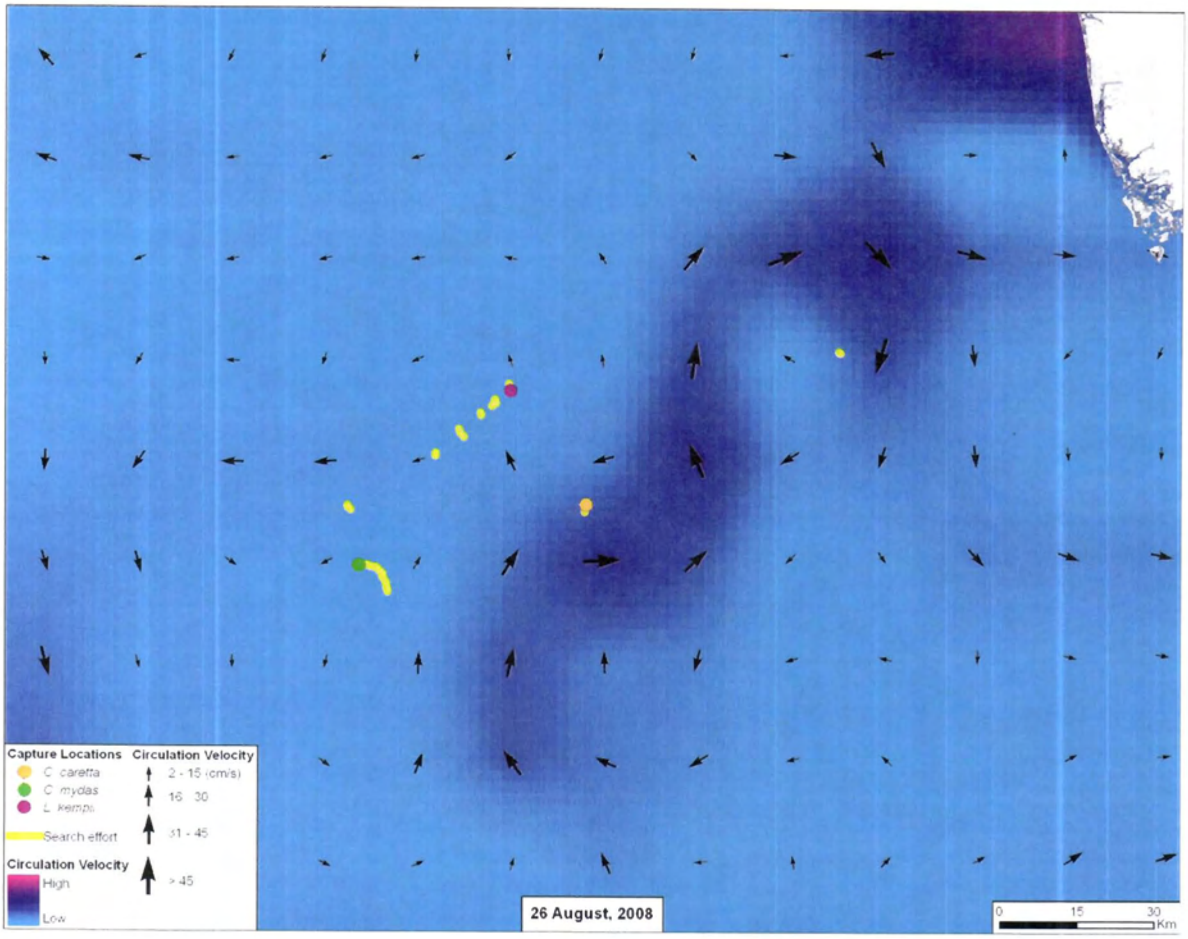

Figure 23. Sea turtle captures/observations and search effort made on 26 August 2008 in the Gulf of Mexico off Marco Island, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

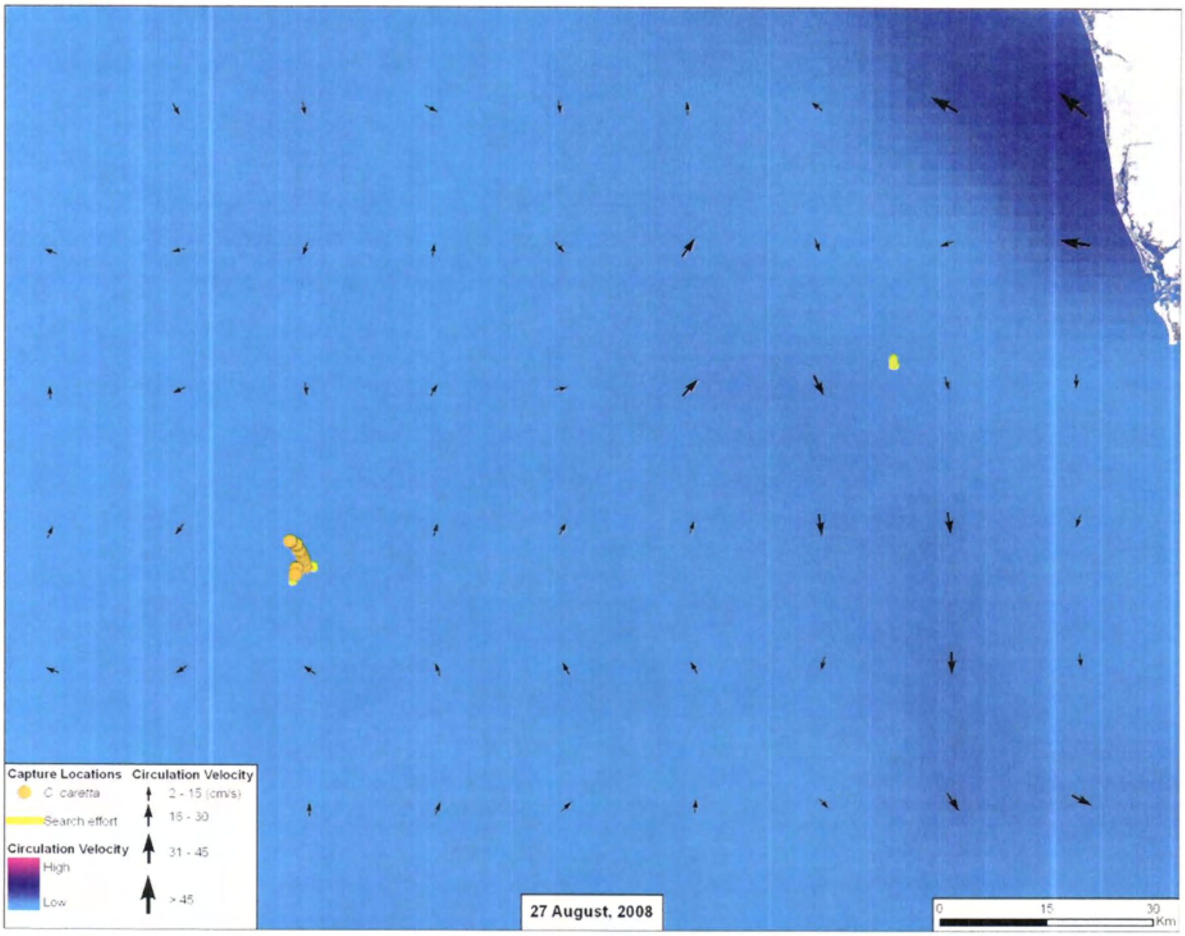

Figure 24. Sea turtle captures/observations and search effort made on 27 August 2008 in the Gulf of Mexico off Marco Island, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

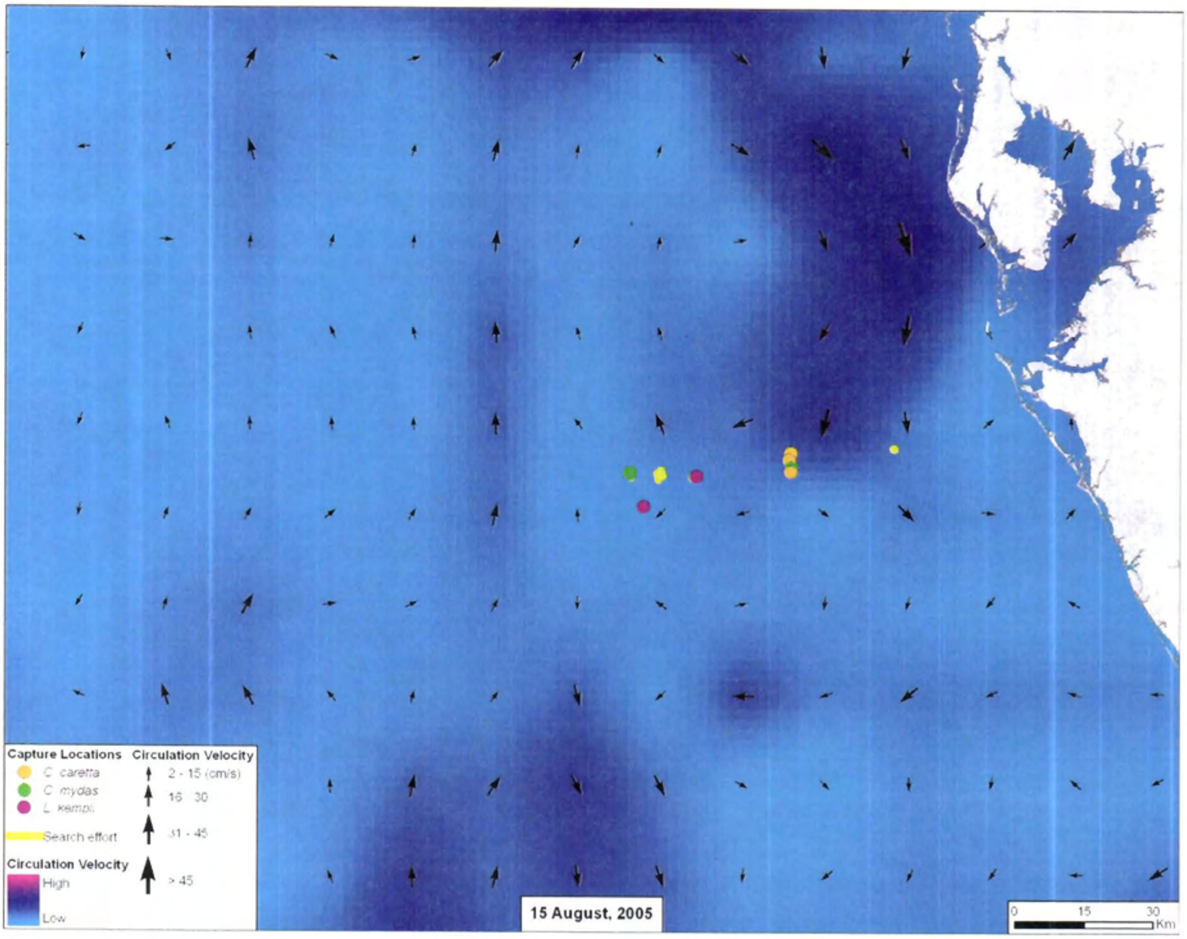

Figure 25. Sea turtle captures/observations and search effort made on 15 August 2005 in the Gulf of Mexico off Sarasota, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

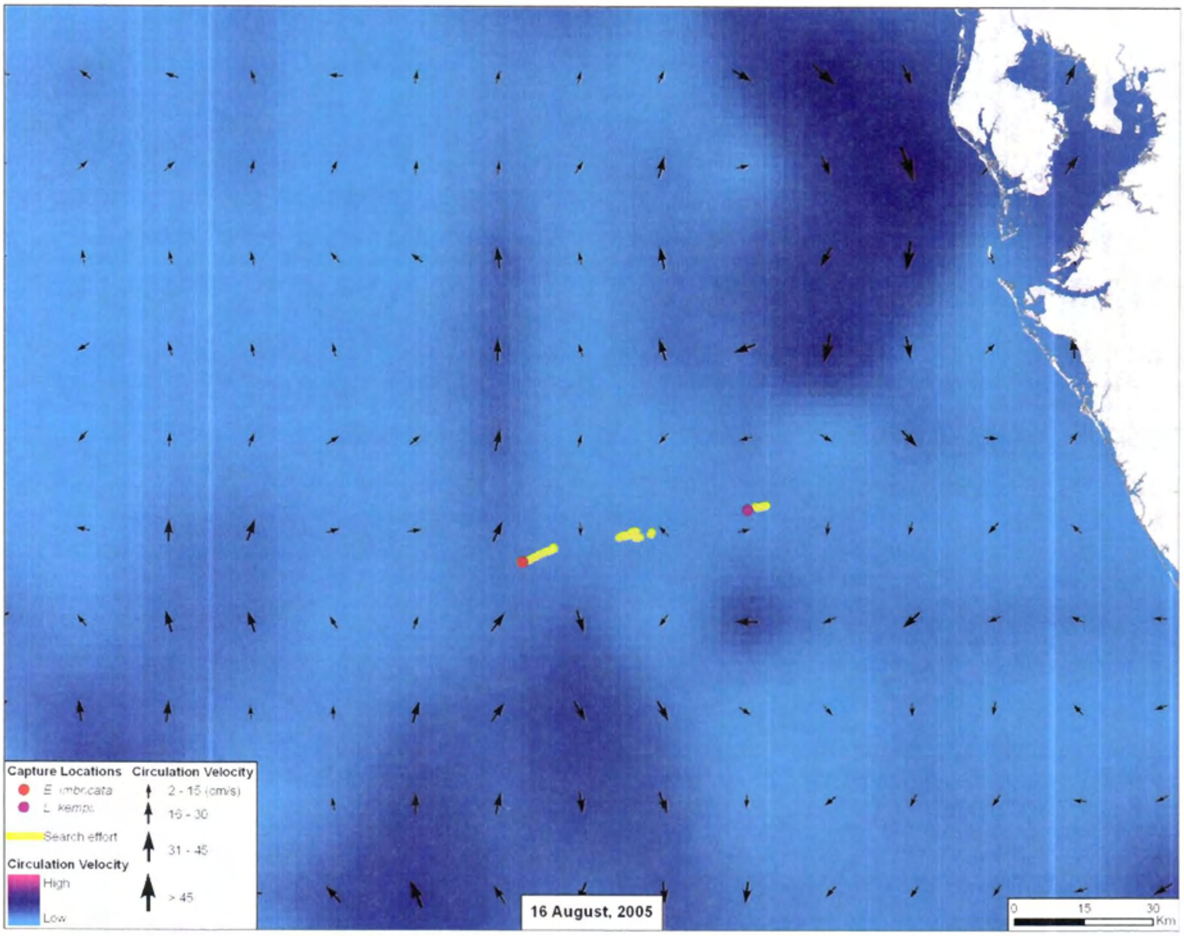

Figure 26. Sea turtle captures/observations and search effort made on 16 August 2005 in the Gulf of Mexico off Sarasota, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

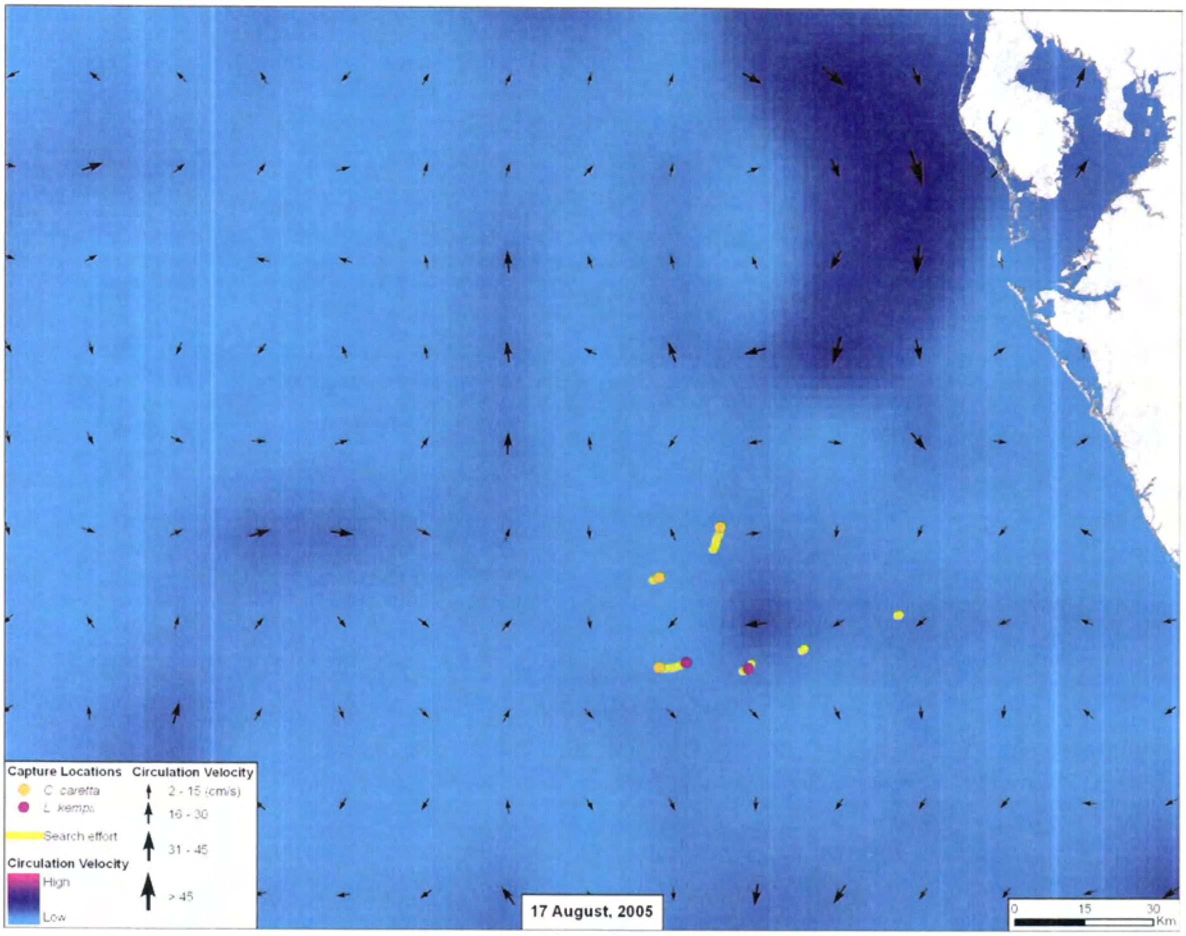

Figure 27. Sea turtle captures/observations and search effort made on 17 August 2005 in the Gulf of Mexico off Sarasota, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

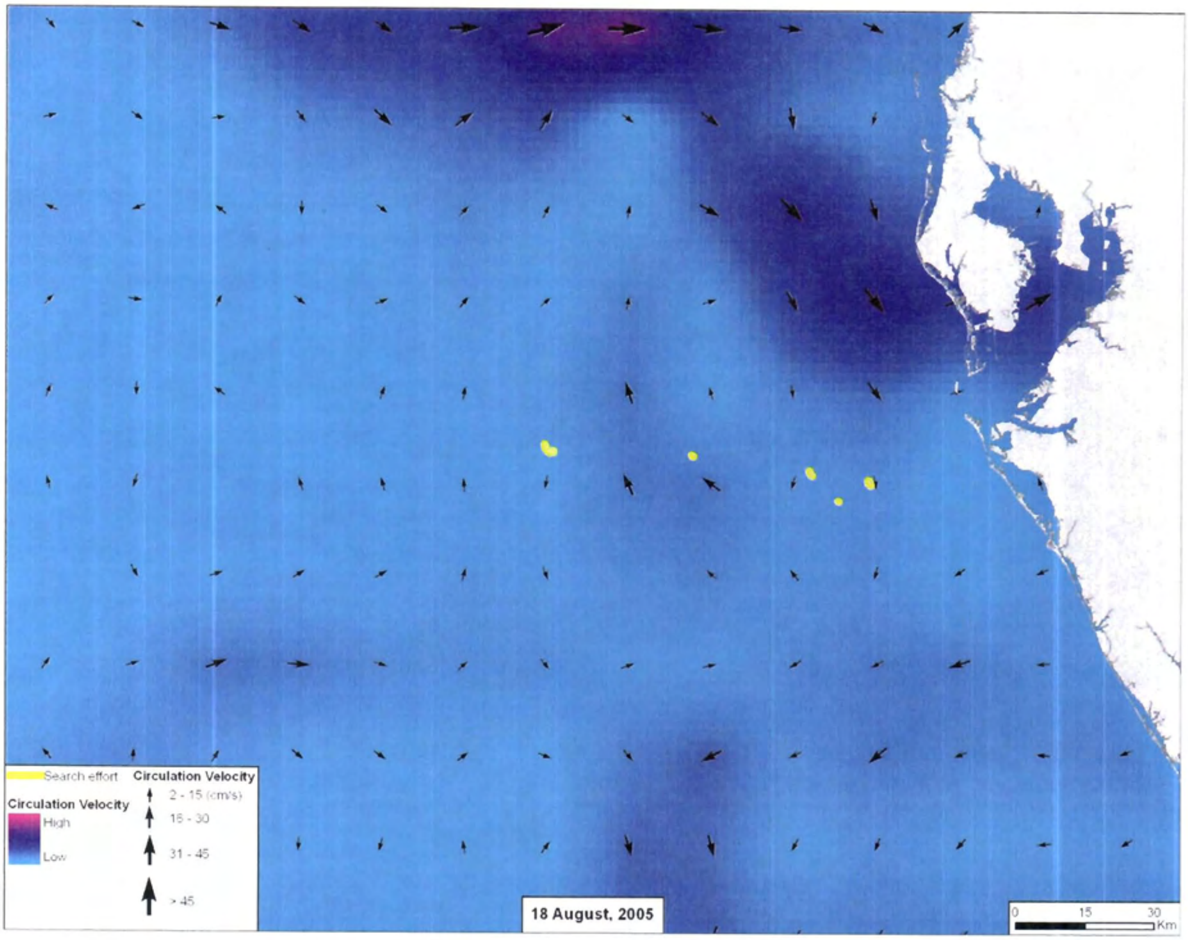

Figure 28. Sea turtle captures/observations and search effort made on 18 August 2005 in the Gulf of Mexico off Sarasota, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

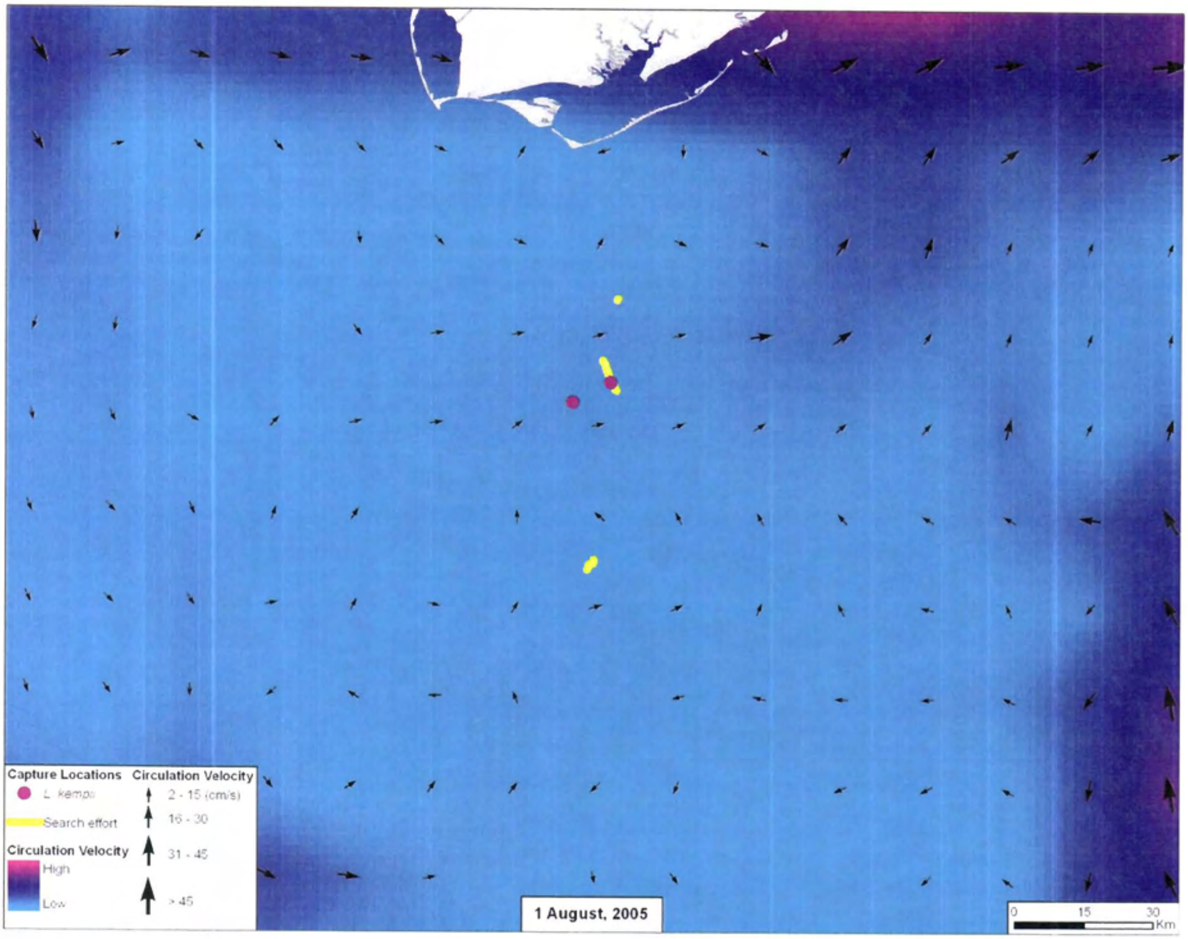

Figure 29. Sea turtle captures/observations and search effort made on 1 August 2005 in the Gulf of Mexico off Apalachicola, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

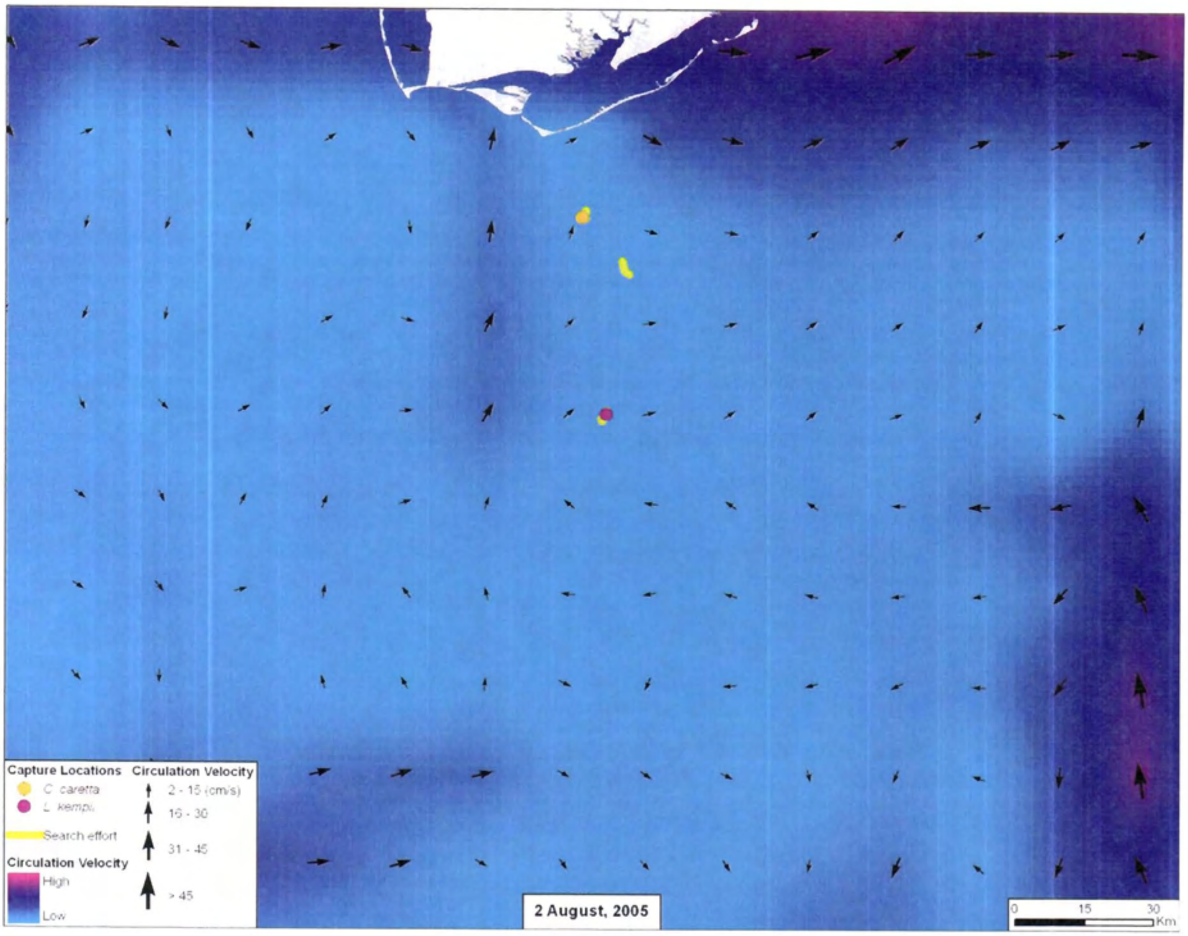

Figure 30. Sea turtle captures/observations and search effort made on 2 August 2005 in the Gulf of Mexico off Apalachicola, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

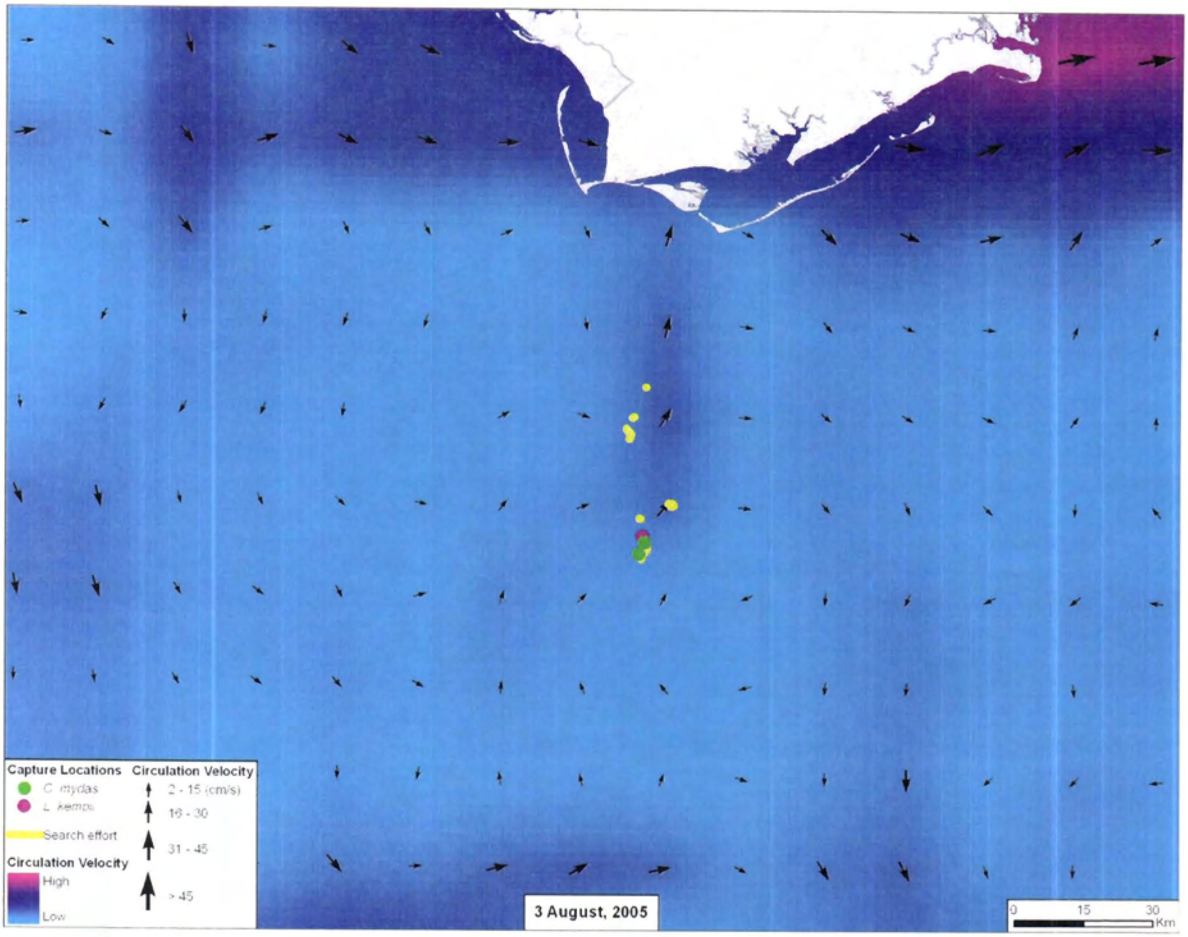

Figure 31. Sea turtle captures/observations and search effort made on 3 August 2005 in the Gulf of Mexico off Apalachicola, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

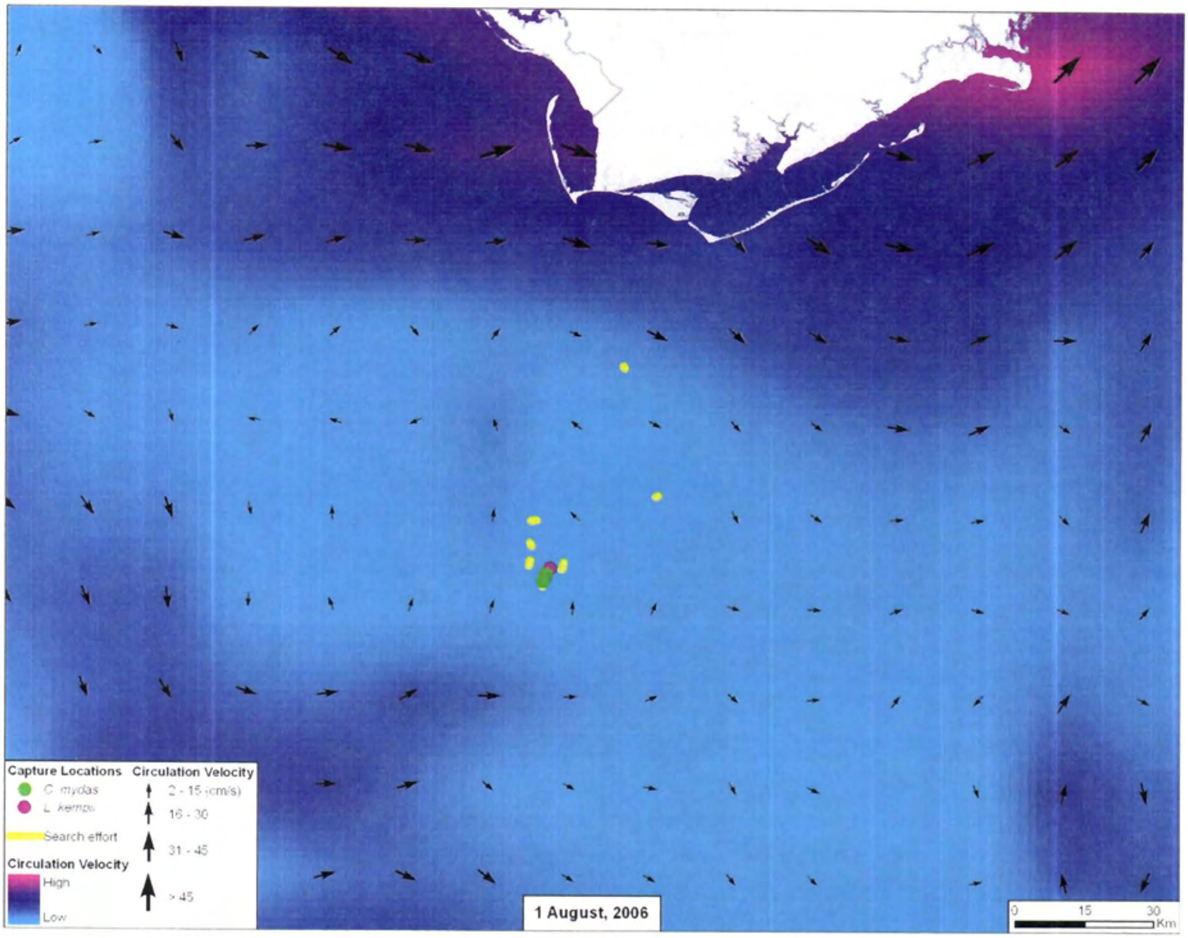

Figure 32. Sea turtle captures/observations and search effort made on 1 August 2006 in the Gulf of Mexico off Apalachicola, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

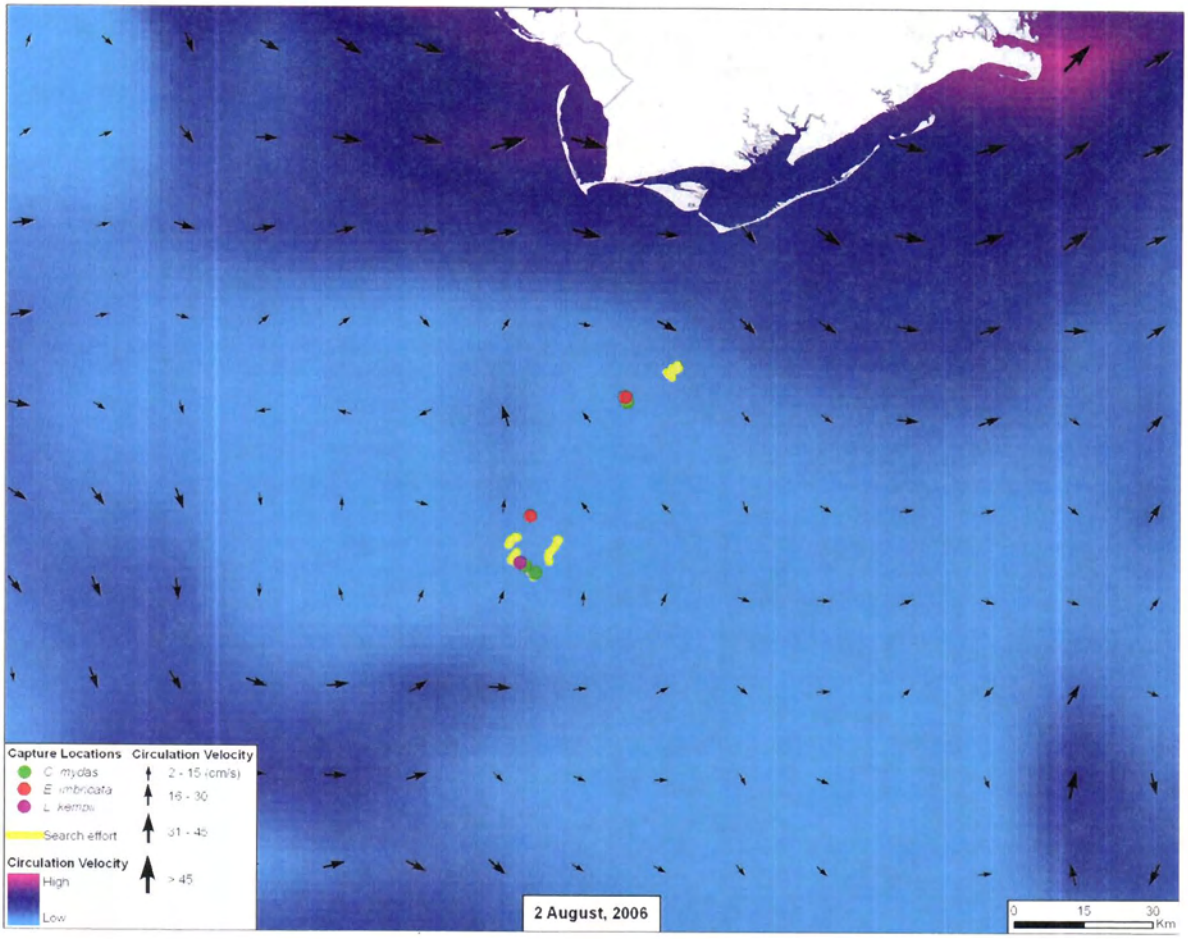

Figure 33. Sea turtle captures/observations and search effort made on 2 August 2006 in the Gulf of Mexico off Apalachicola, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

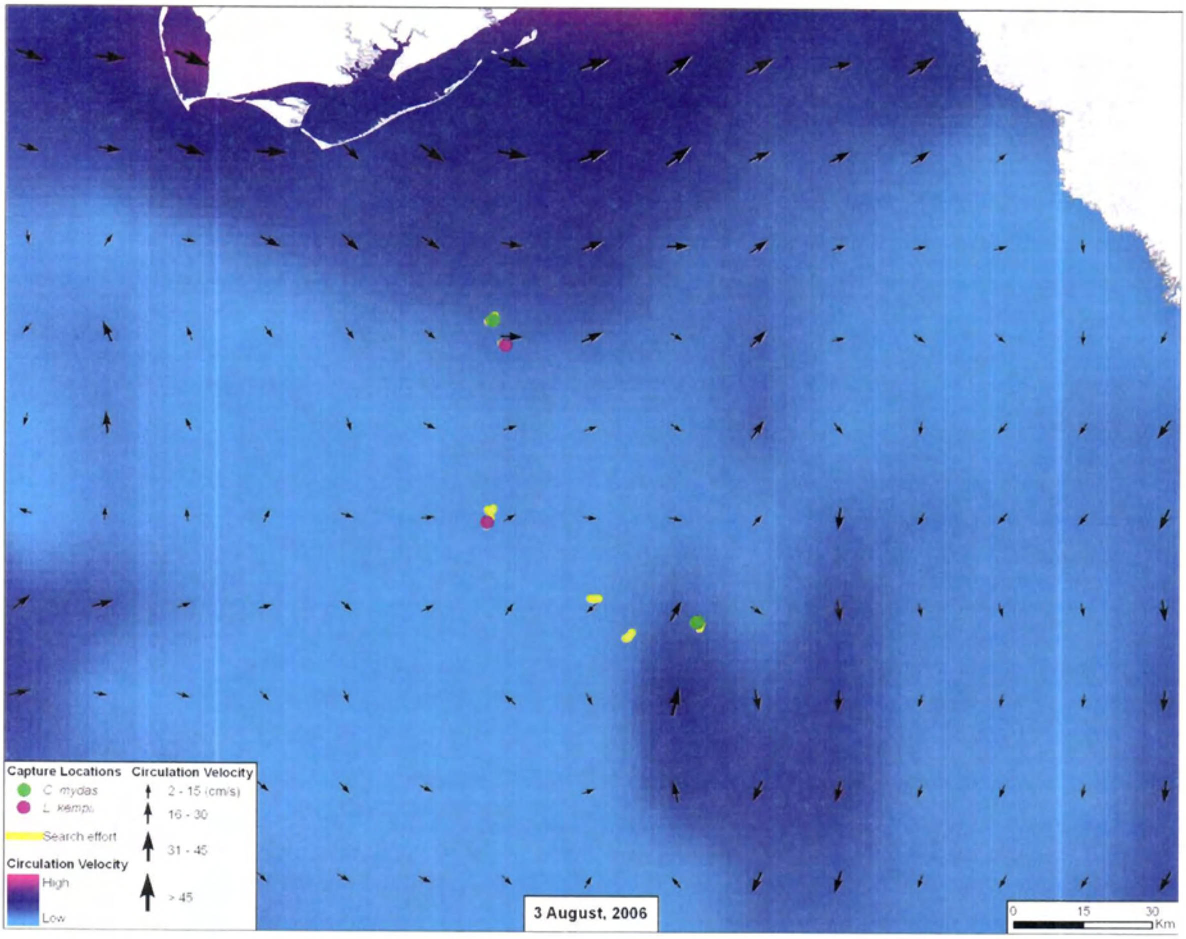

Figure 34. Sea turtle captures/observations and search effort made on 3 August 2006 in the Gulf of Mexico off Apalachicola, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

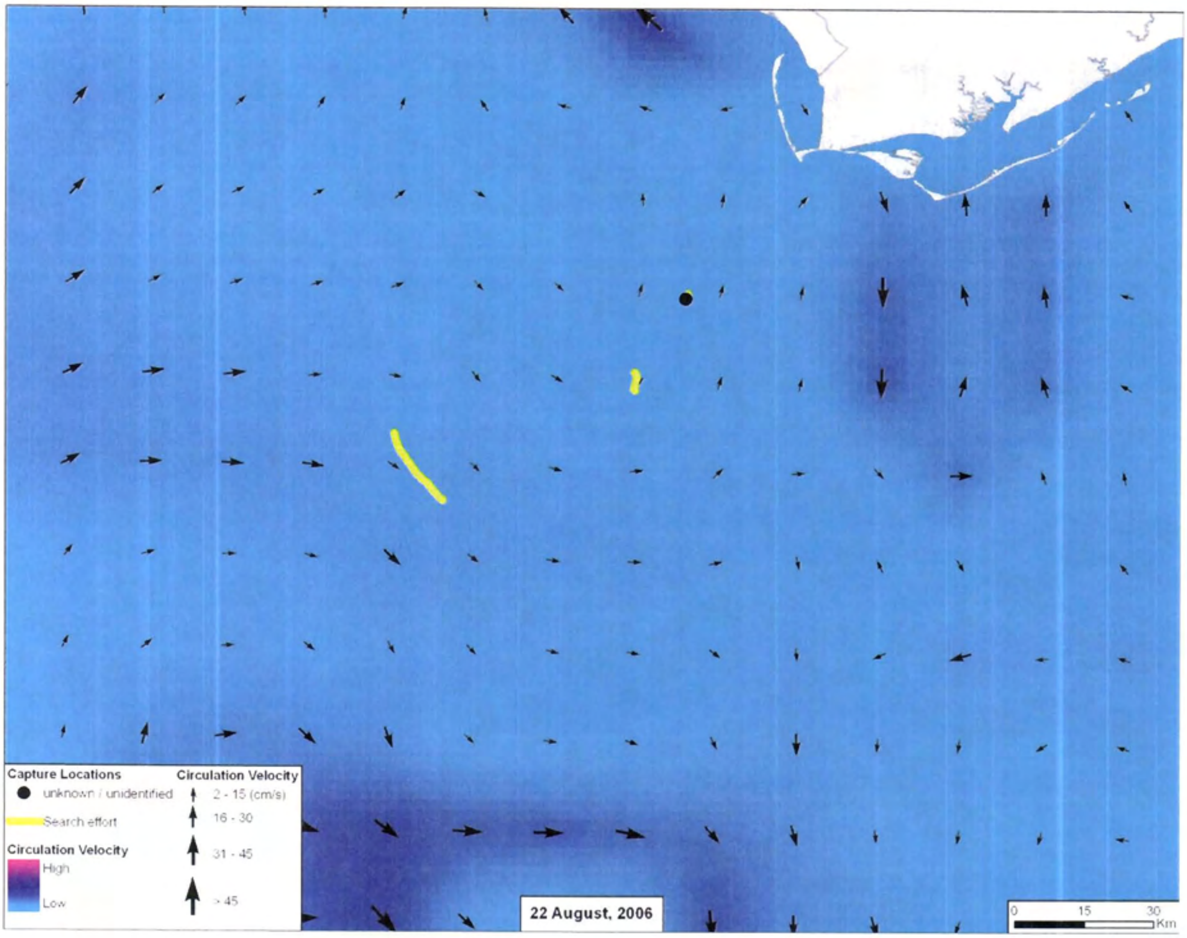

Figure 35. Sea turtle captures/observations and search effort made on 22 August 2006 in the Gulf of Mexico off Apalachicola, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

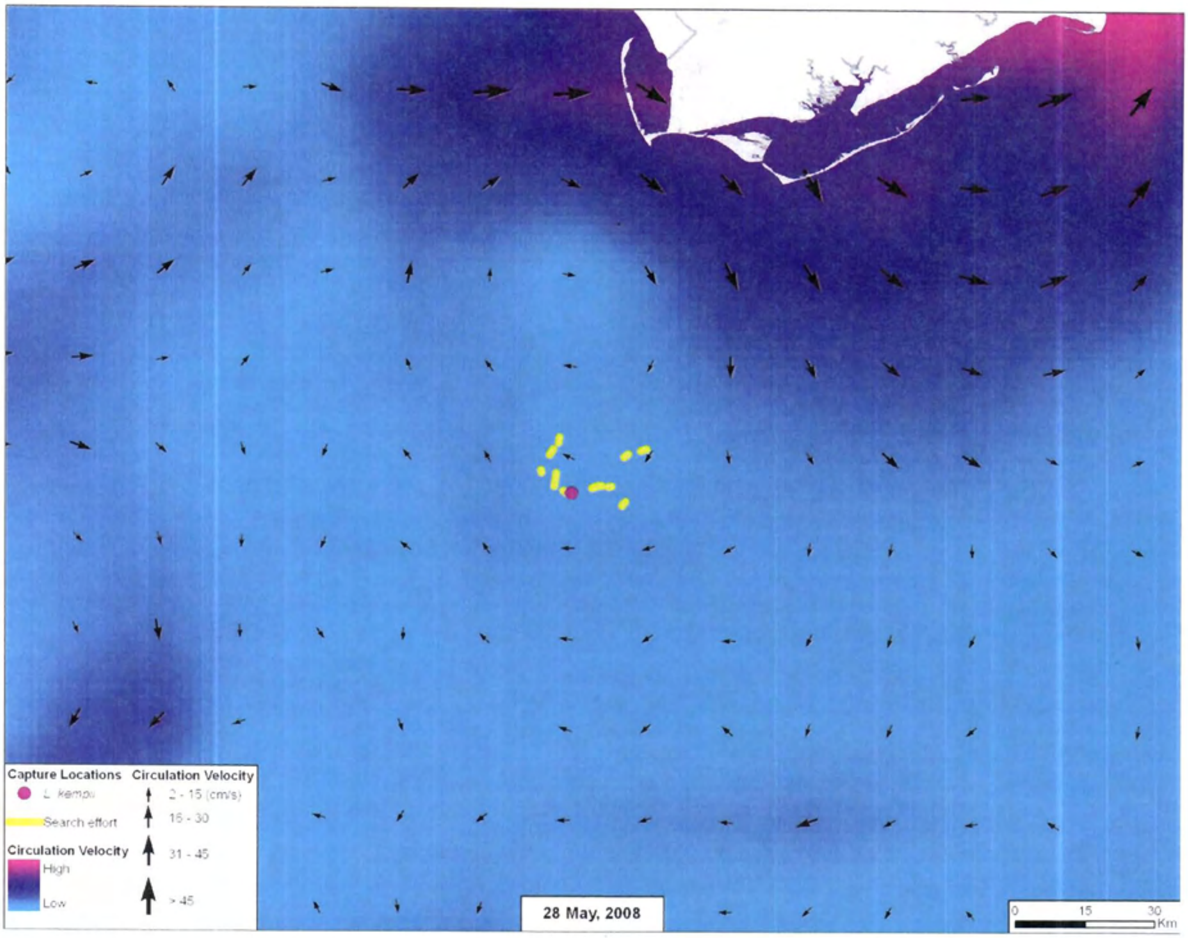

Figure 36. Sea turtle captures/observations and search effort made on 28 May 2008 in the Gulf of Mexico off Apalachicola, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

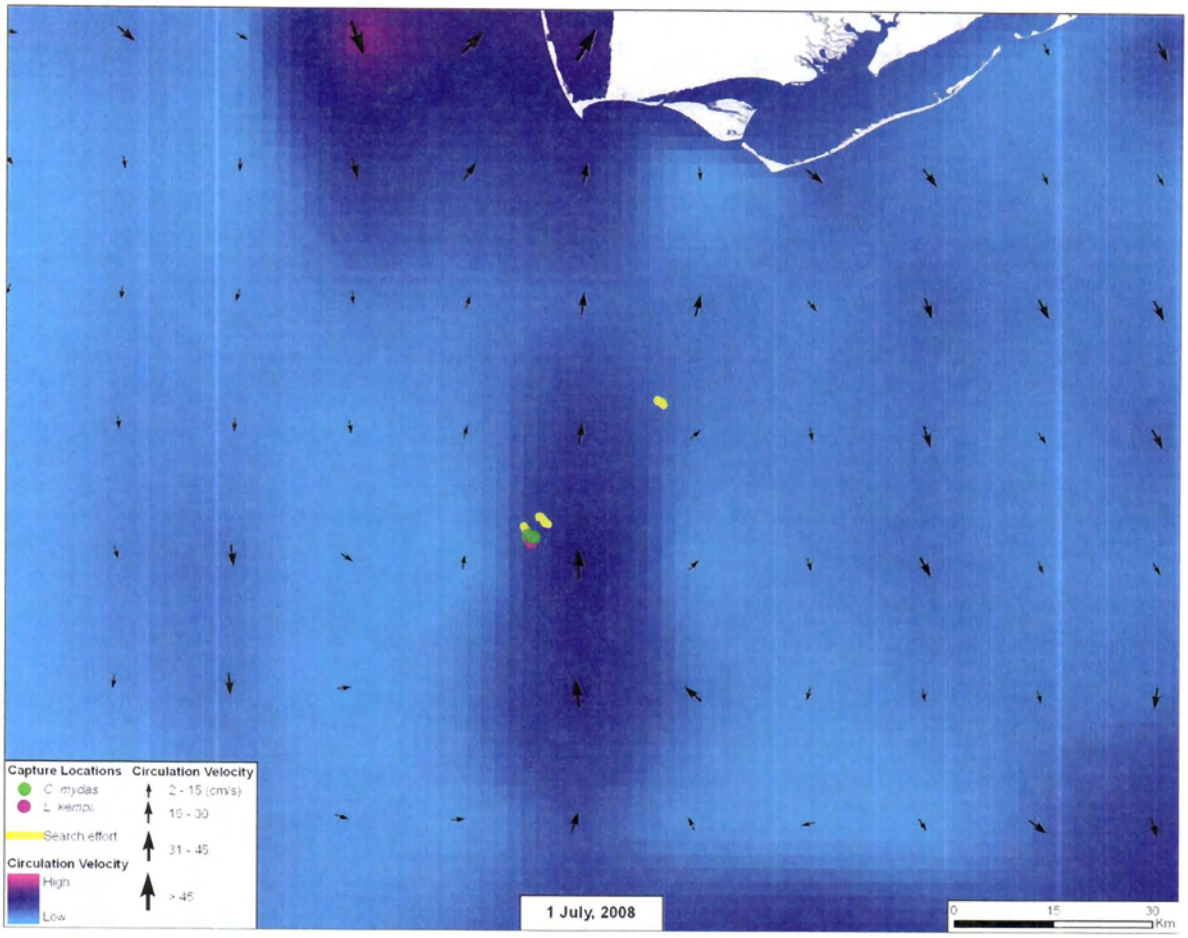

Figure 37. Sea turtle captures/observations and search effort made on 1 July 2008 in the Gulf of Mexico off Apalachicola, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

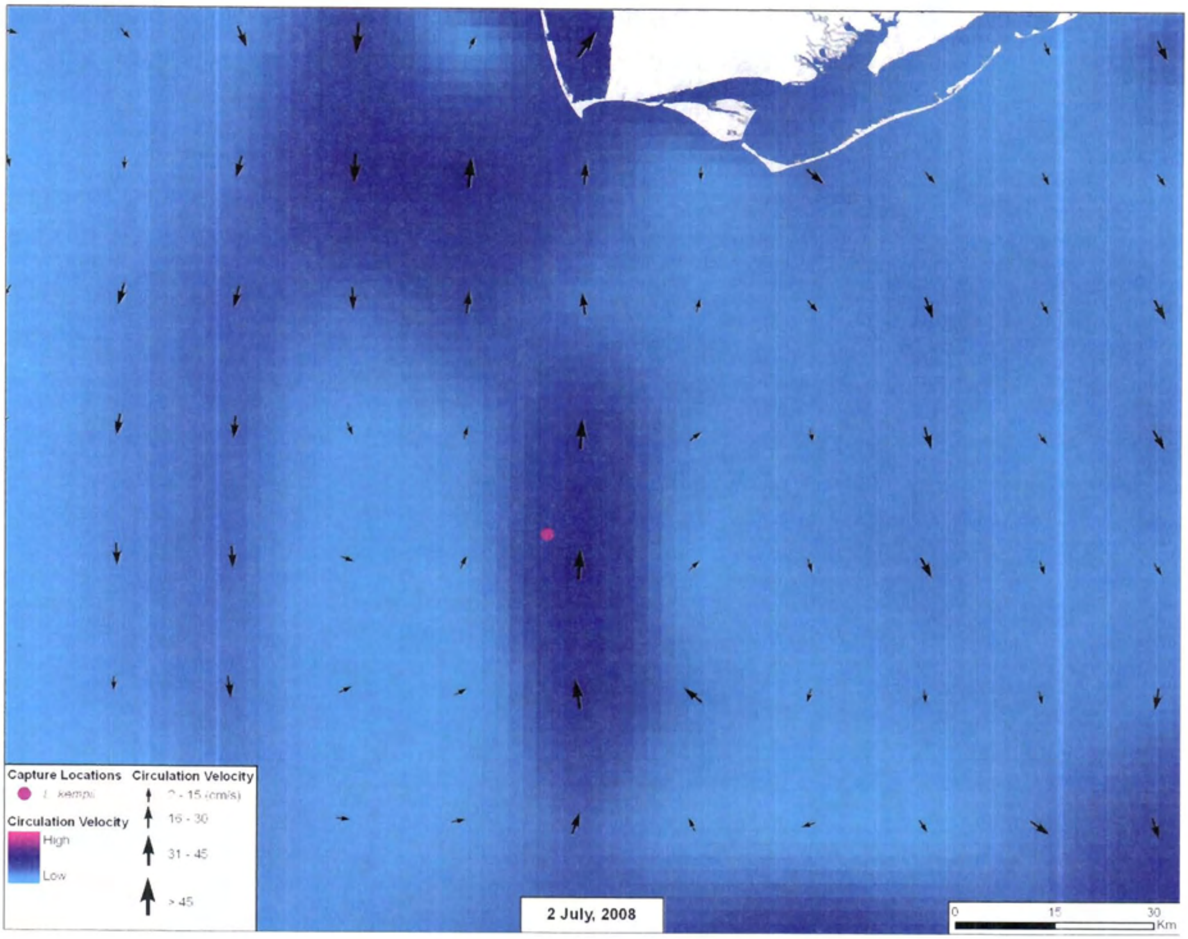

Figure 38. Sea turtle captures/observations and search effort made on 2 July 2008 in the Gulf of Mexico off Apalachicola, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

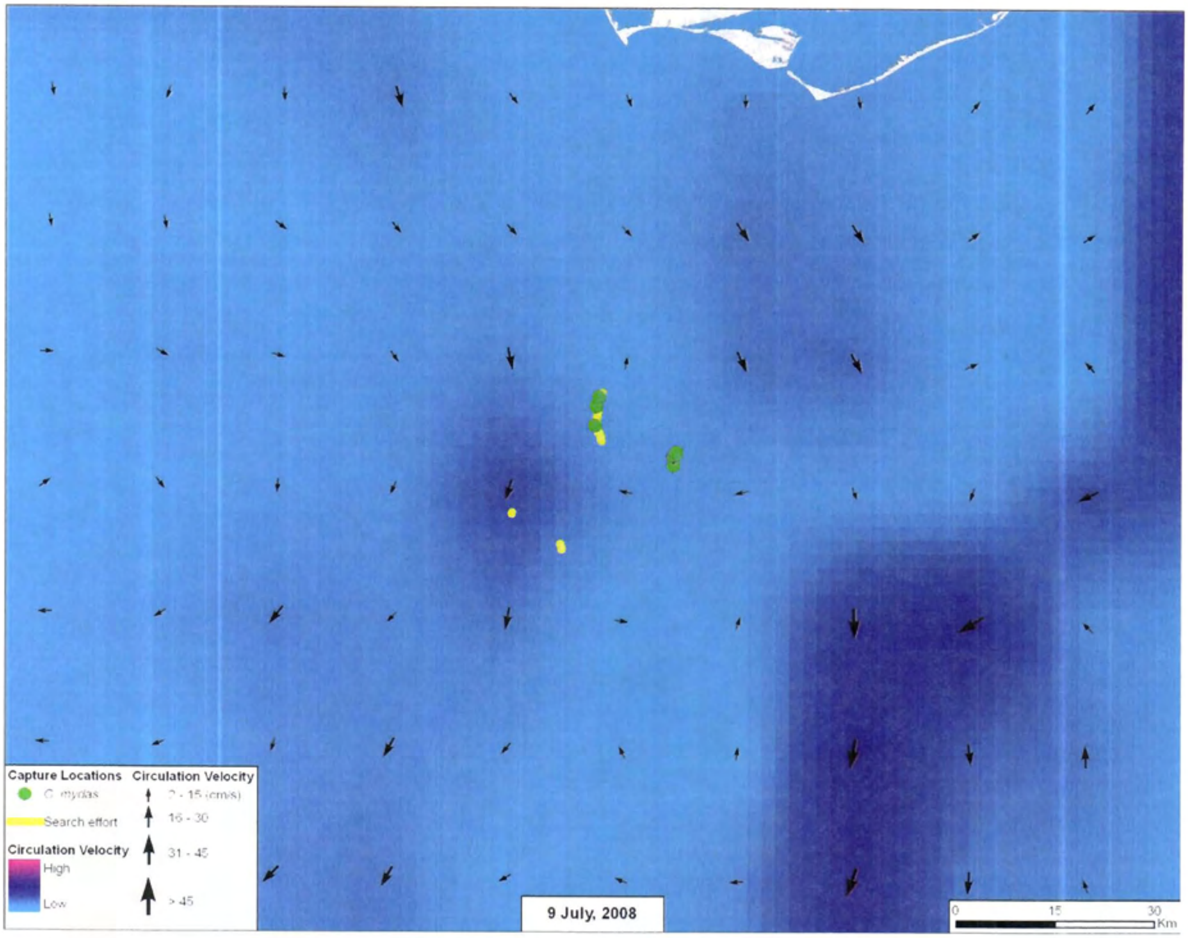

Figure 39. Sea turtle captures/observations and search effort made on 9 July 2008 in the Gulf of Mexico off Apalachicola, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

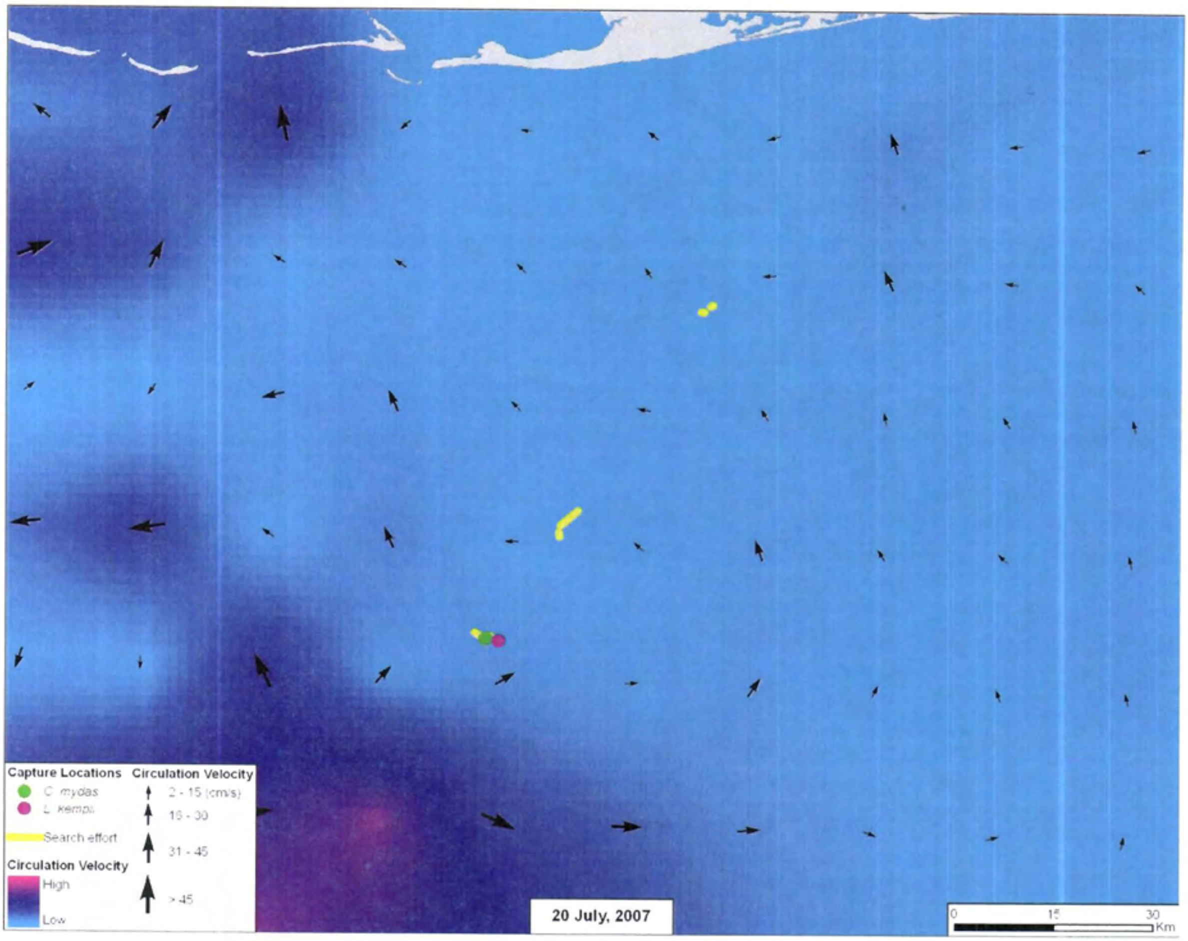

Figure 40. Sea turtle captures/observations and search effort made on 20 July 2008 in the Gulf of Mexico off Pensacola, Florida. Surface circulation vectors were from interpolation of sea-surface height anomaly data recorded through multiple sensors (Jason-1, TOPEX, ERS-2, ENVISAT, and GFO). The data described 10-day periods and had a 0.25-degree spatial resolution. Data were available online through the NOAA Coast Watch Caribbean/Gulf of Mexico Regional Node (http://www.aoml.noaa.gov/phod/dataphod/work/trinanes/INTERFACE/index.html).

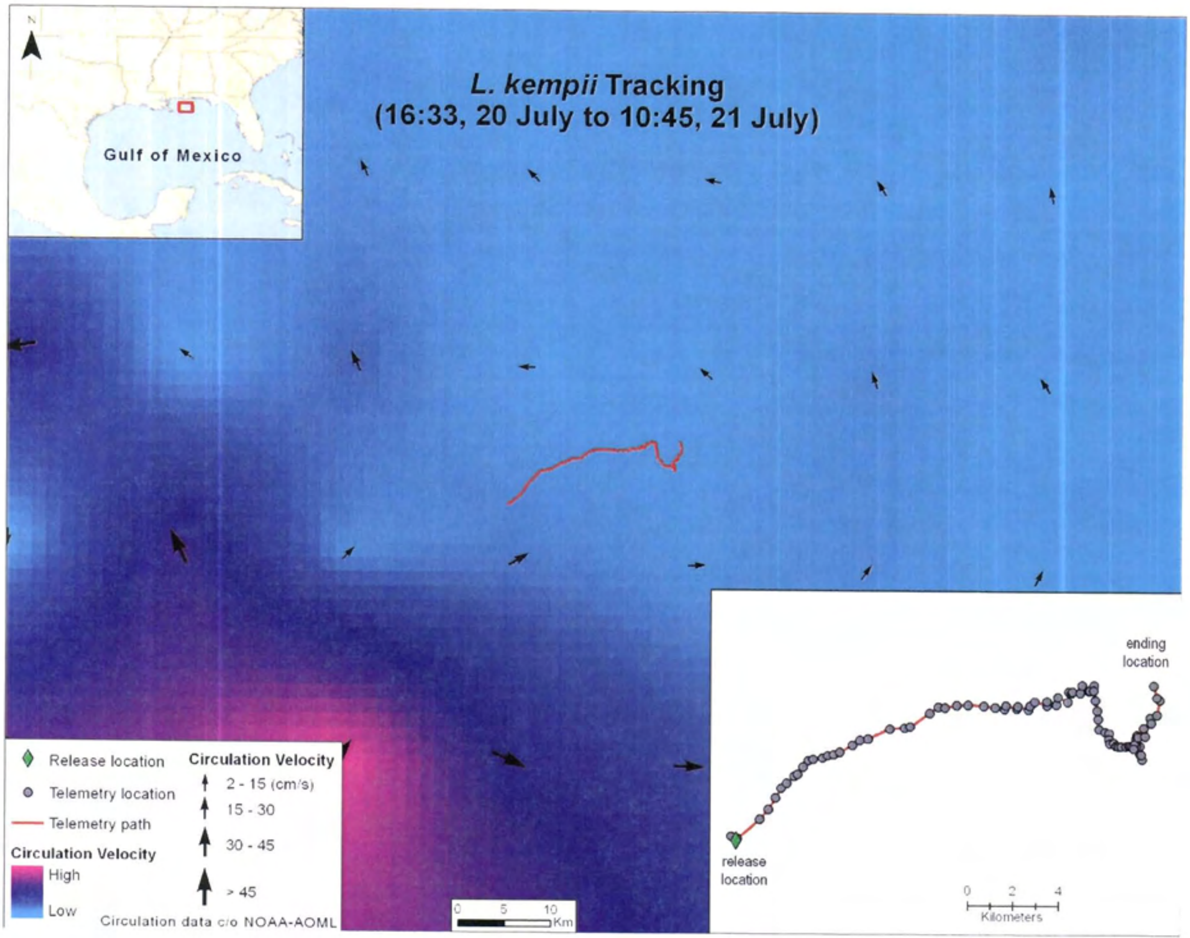

Figure 41. Travel path of a 1.70 kg, juvenile Kemp's ridley tracked for 18.5 hours beginning 20 July 2007. The turtle was fitted with a depth recorder following its initial capture and release in the Gulf of Mexico, approximately 66 NM southwest from Pensacola Bay, Florida. Positions were estimated from tracking vessel locations where sonic reception was strong, within approximately 300 m of the turtle. Release time was 15:28 and recapture time was 09:58. During the period, sunset was 20:51 and sunrise was 07:03 EDT.

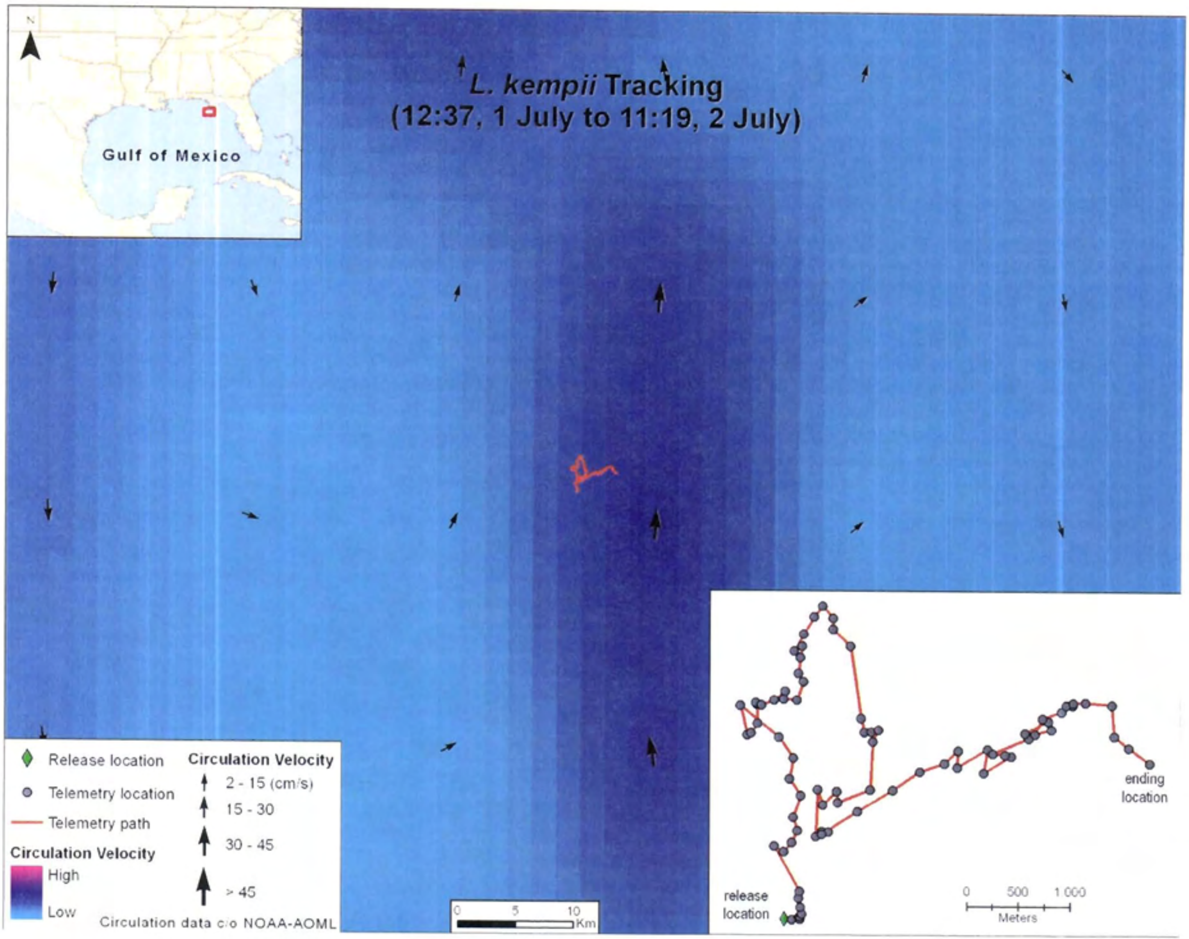

Figure 42. Travel path of a 1.85 kg, juvenile Kemp's ridley tracked for 23.1 hours beginning 1 July 2008. The turtle was fitted with a depth recorder following its initial capture and release in the Gulf of Mexico, approximately 45 NM southwest from Apalachicola Bay, Florida. Positions were estimated from tracking vessel locations where sonic reception was strong, within approximately 300 m of the turtle. Release time was 12:36 and recapture time was 11:43. During the period, sunset was 20:44 and sunrise was 06:49 EDT.

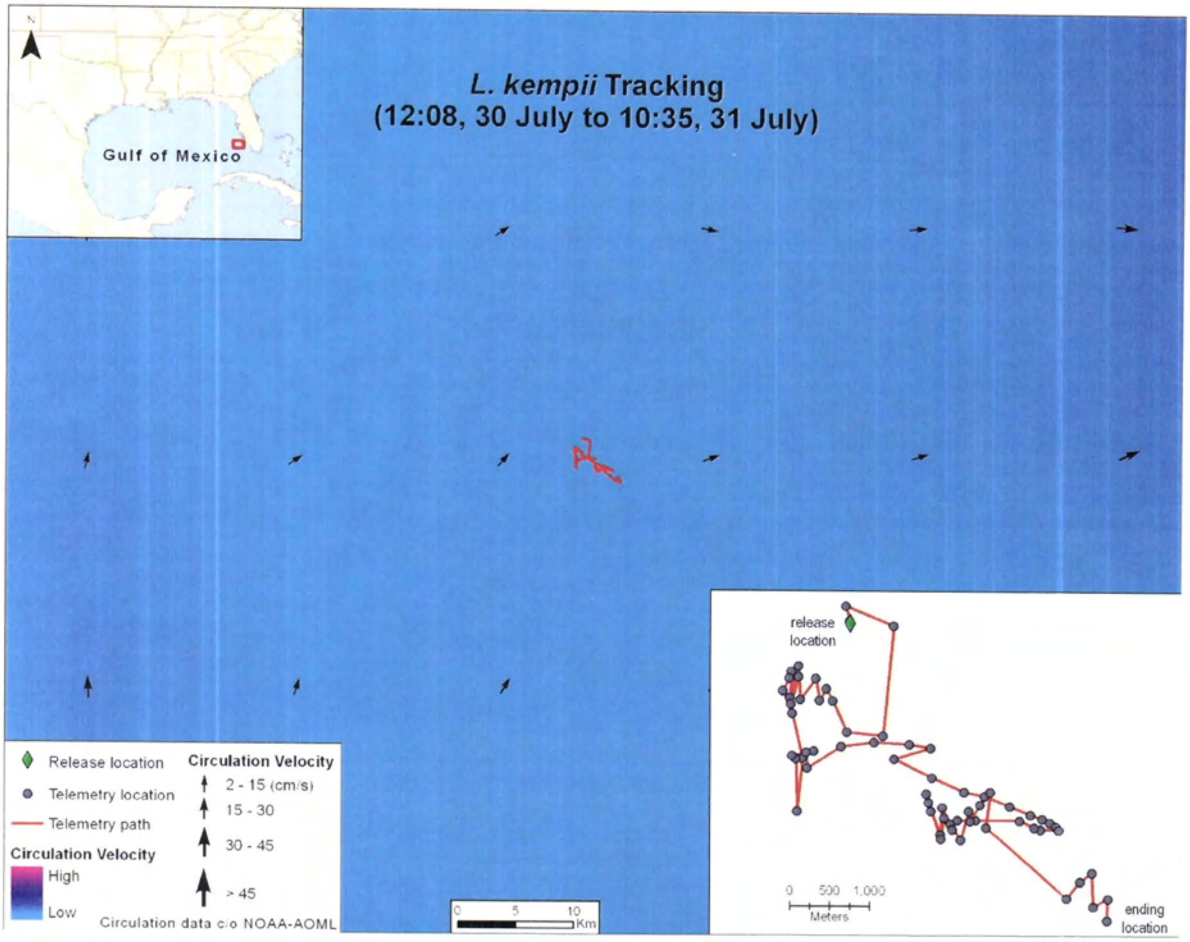

Figure 43. Travel path of a 2.10 kg, juvenile Kemp's ridley tracked for 22.6 hours beginning 30 July 2008. The turtle was fitted with a depth recorder following its initial capture and release in the Gulf of Mexico, approximately 43 NM west-southwest from Collier Bay, Florida. Positions were estimated from tracking vessel locations where sonic reception was strong, within approximately 300 m of the turtle. Release time was 12:06 and recapture time was 10:43. During the period, sunset was 20:17 and sunrise was 06:54 EDT.

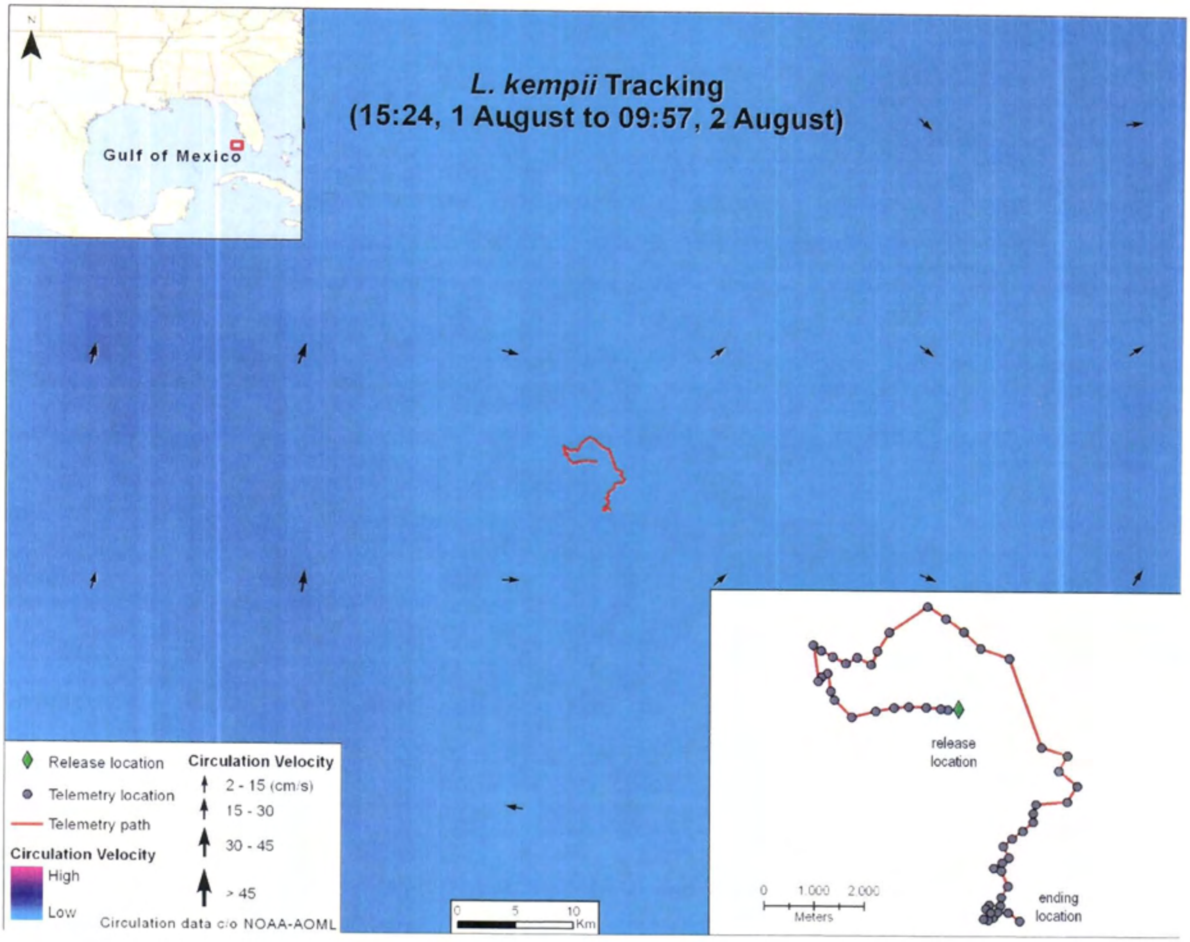

Figure 44. Travel path of a 2.7 kg (est.), juvenile Kemp's ridley tracked for 18.6 hours beginning 1 August 2008. The turtle was fitted with a depth recorder following its initial capture and release in the Gulf of Mexico, approximately 53 NM west-southwest from Collier Bay, Florida. Positions were estimated from tracking vessel locations where sonic reception was strong, within approximately 300 m of the turtle. Release time was 15:24 and recapture time was 09:57. During the period, sunset was 20:16 and sunrise was 06:55 EDT. This turtle's depth recorder was not recovered.

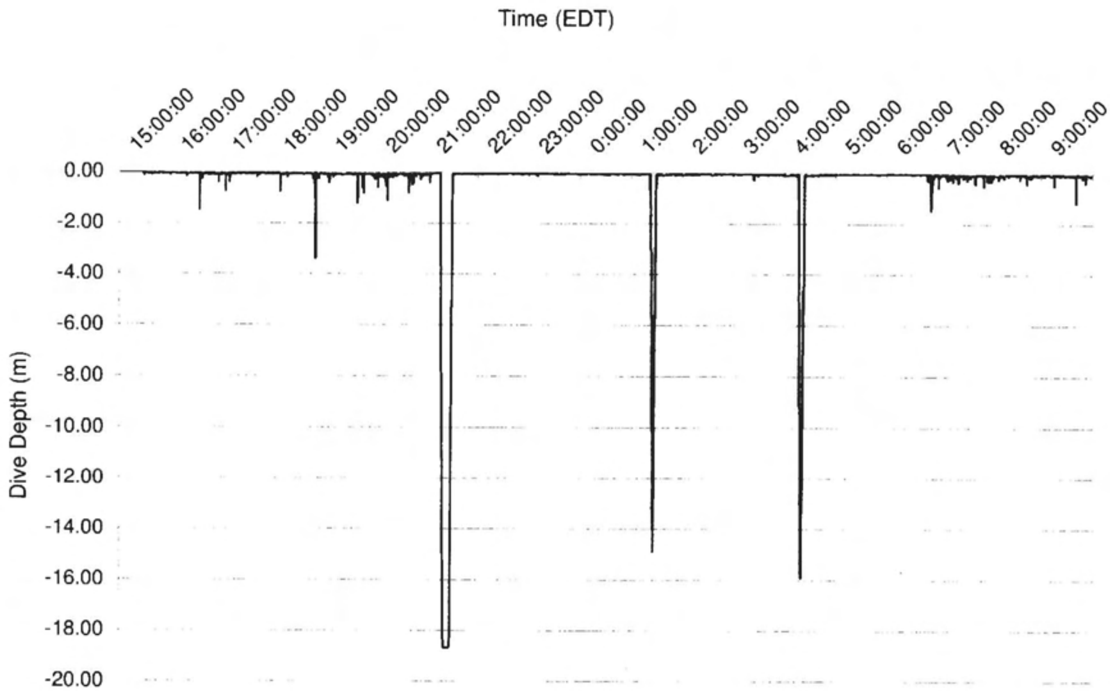

Figure 45. Dive depths of a 1.70 kg, juvenile Kemp's ridley tracked for 18.5 hours beginning 20 July 2007. The turtle was fitted with a depth recorder following its initial capture and release in the Gulf of Mexico, approximately 66 NM southwest from Pensacola Bay, Florida. Average water depth was approximately 55 m. Release time was 15:28 and recapture time was 09:58. During the period, sunset was 20:51 and sunrise was 07:03 EDT. The depth recorder logged depths at 6-sec intervals.

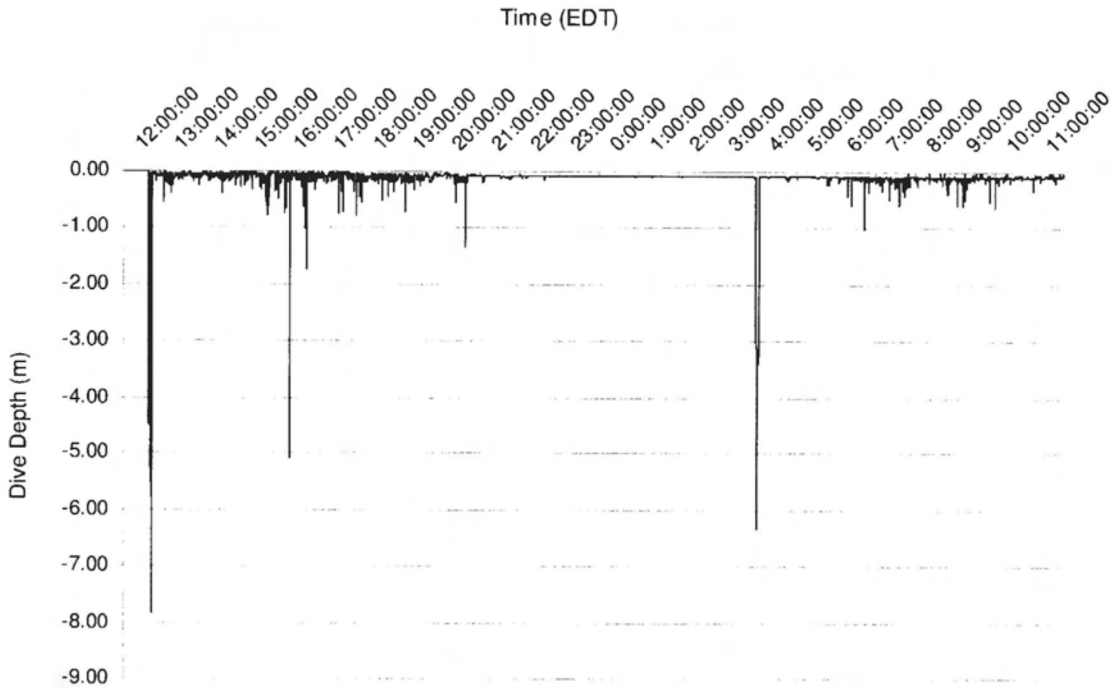

Figure 46. Dive depths of a 1.85 kg, juvenile Kemp's ridley tracked for 23.1 hours beginning 1 July 2008. The turtle was fitted with a depth recorder following its initial capture and release in the Gulf of Mexico, approximately 45 NM southwest from Apalachicola Bay, Florida. Average water depth was approximately 56 m. Release time was 12:36 and recapture time was 11:43. During the period, sunset was 20:44 and sunrise was 06:49 EDT. The depth recorder logged depths at 6-sec intervals.

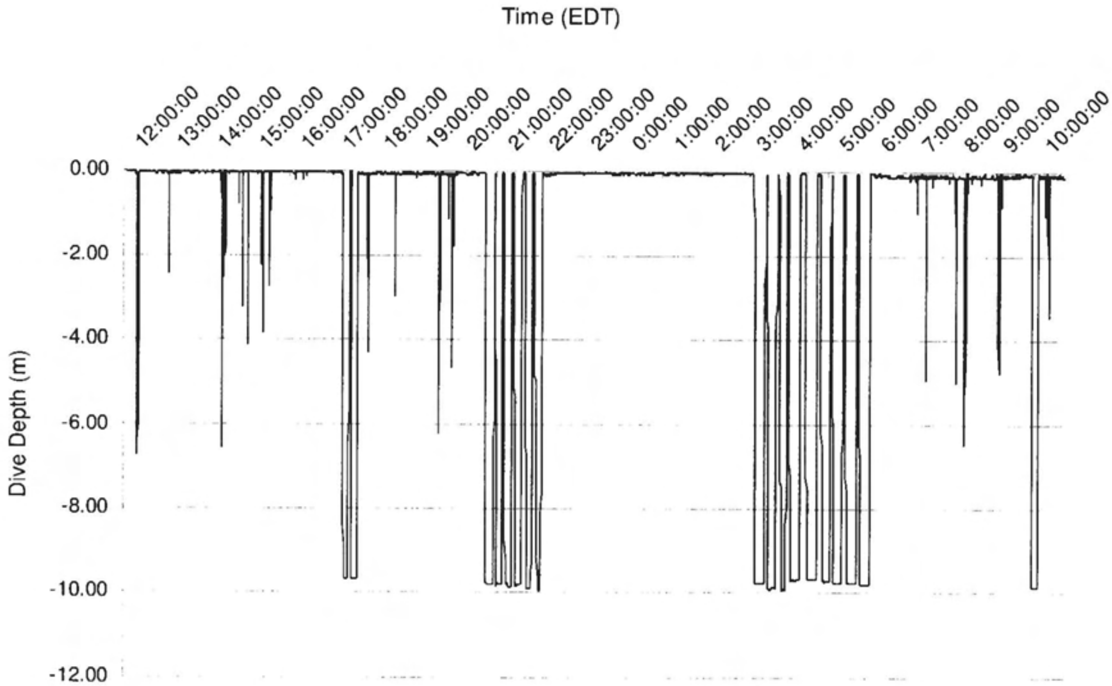

Figure 47. Dive depths of a 2.10 kg, juvenile Kemp's ridley tracked for 22.6 hours beginning 30 July 2008. The turtle was fitted with a depth recorder following its initial capture and release in the Gulf of Mexico, approximately 43 NM west-southwest from Collier Bay, Florida. Average water depth was approximately 33 m. Release time was 12:06 and recapture time was 10:43. During the period, sunset was 20:17 and sunrise was 06:54 EDT. The depth recorder logged depths at 6-sec intervals.

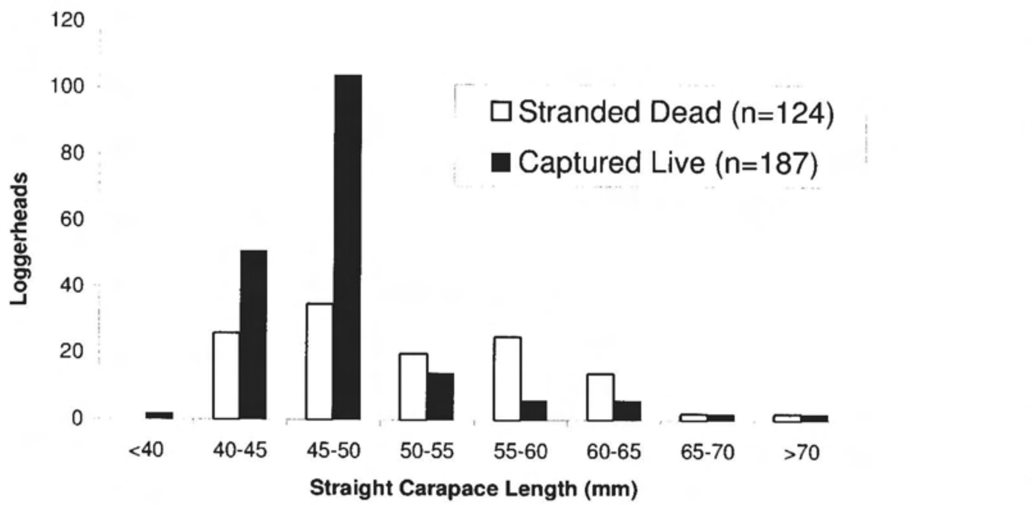

Figure 48. A size comparison of post-hatchling loggerhead turtles captured from the Atlantic (Captured Live) or stranded following storm events on Florida's Atlantic coast (Stranded Dead). This sample of dead stranded turtles was used in an analysis of diet and ingested debris (see text).

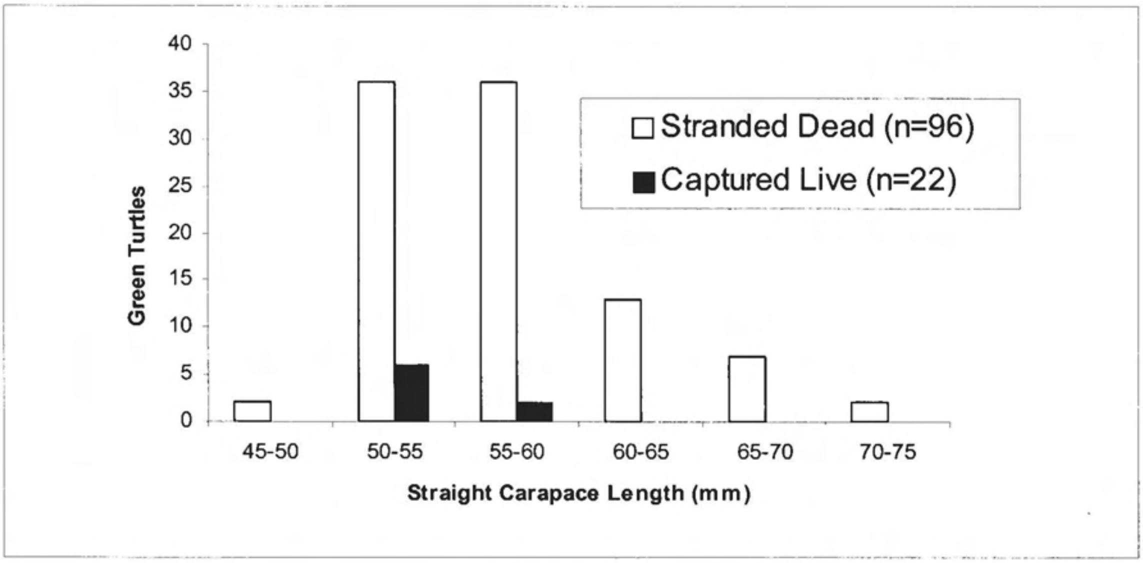

Figure 49. A size comparison of post-hatchling green turtles turtles captured from the Atlantic (Captured Live) or stranded following storm events on Florida's Atlantic coast (Stranded Dead). This sample of dead stranded turtles was used in an analysis of diet and ingested debris (see text).

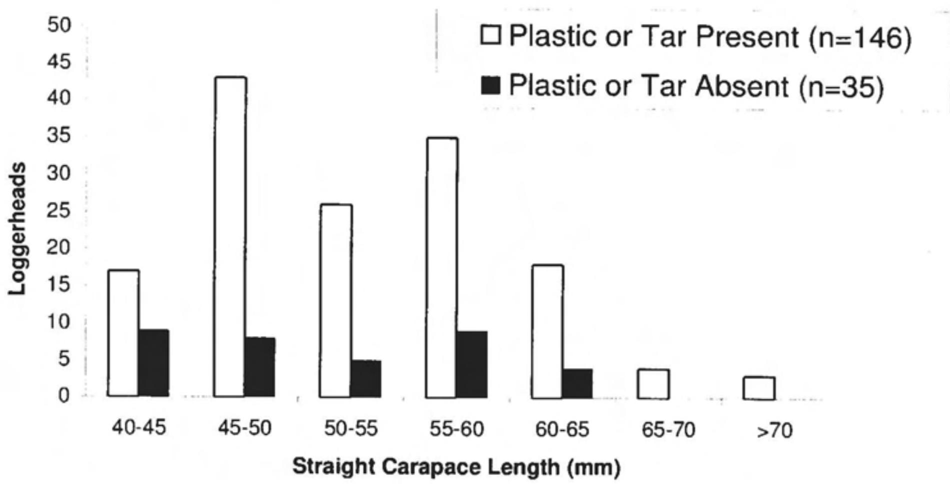

Figure 50. Size (straight carapace length, SCL, mm) frequencies of 181 post-hatchling loggerheads with and without evidence of plastic or tar ingestion found from a complete examination of their gut contents. All turtles in this analysis stranded dead following storm events on Florida's Atlantic coast between 1996 and 2007.

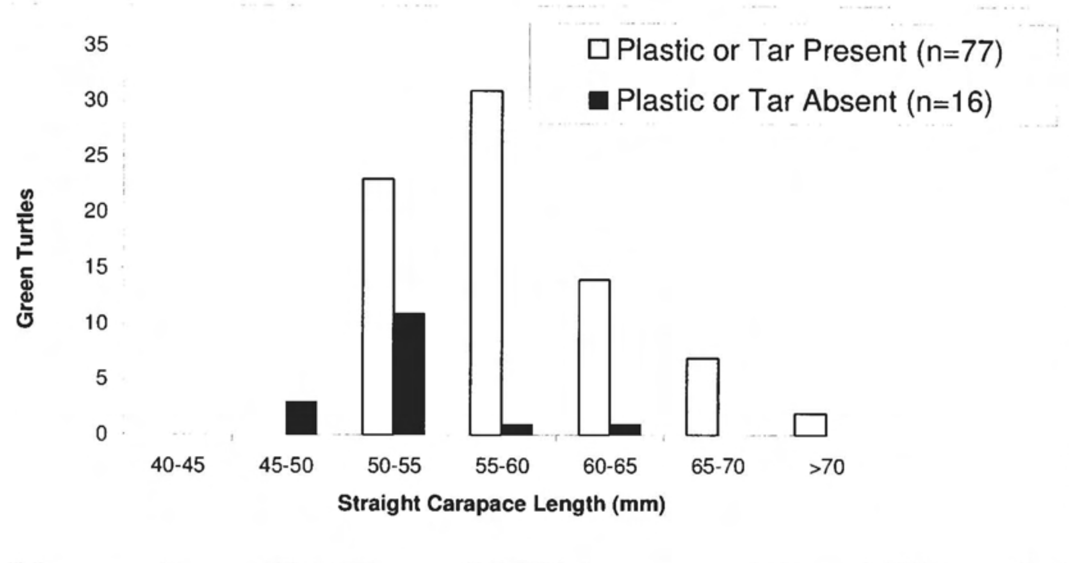

Figure 51. Size (straight carapace length, SCL, cm) frequencies of 93 post-hatchling green turtles with and without evidence of plastic or tar ingestion found from a complete examination of their gut contents. All turtles in this analysis stranded dead following storm events on Florida's Atlantic coast between 1996 and 2007.

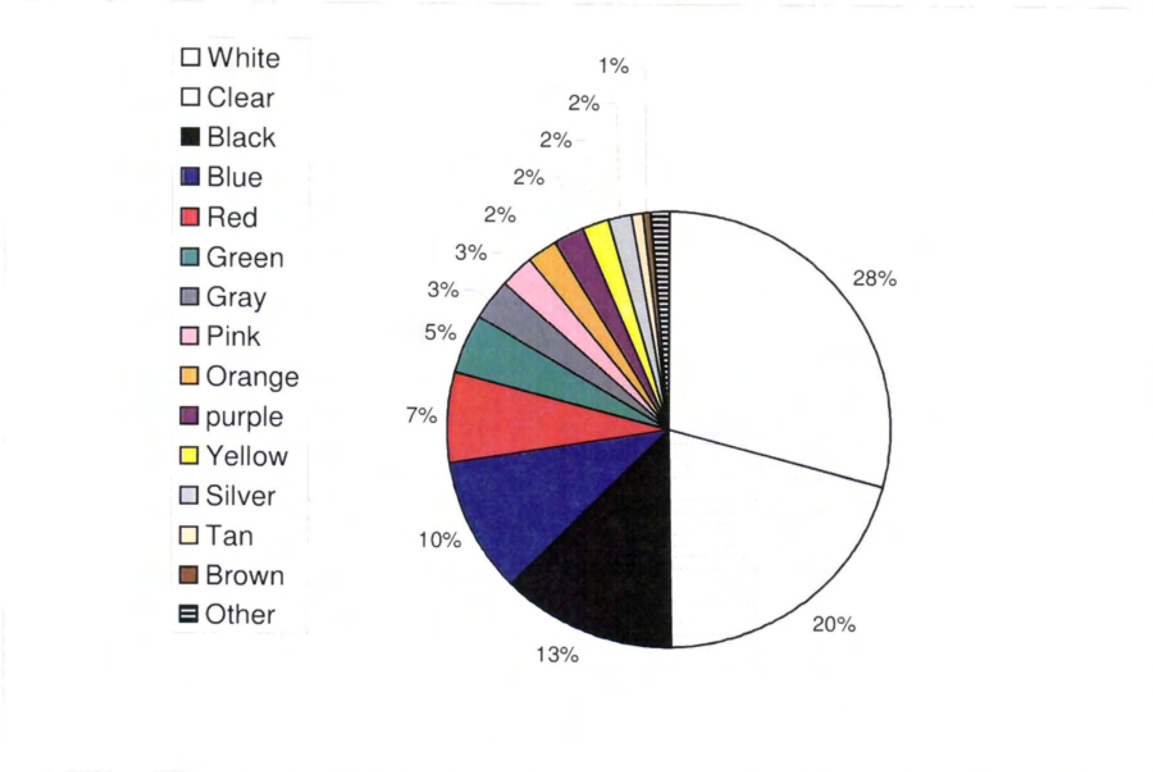

Figure 52. Proportions of plastics colors ingested by 122 post-hatchling loggerheads stranded dead following storm events on Florida's Atlantic coast between 1996 and 2007. The vast majority of synthetic material was plastic. Black material was predominantly tar.

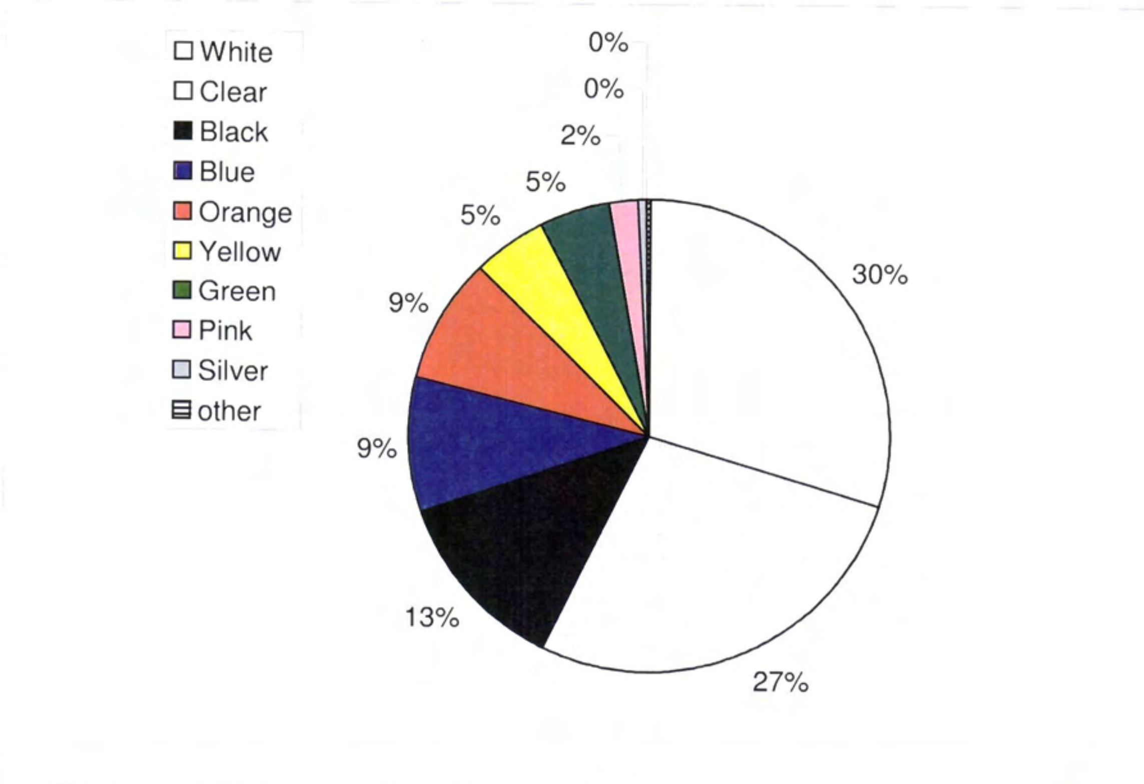

Figure 53. Proportions of colors of synthetic materials ingested by 83 post-hatchling green turtles stranded dead following storm events on Florida's Atlantic coast between 1996 and 2007. The vast majority of synthetic material was plastic. Black material was predominantly tar.

Table 1. Estimated sea turtles per square kilometer within epi-pelagic habitat (*Sargassum* lines) in the Atlantic Ocean and Gulf of Mexico off Florida (USA, Fig. 1). Florida port locations designate the nearest landfall to offshore epi-pelagic habitat searched during the years 2005—2008. Density estimates were made using turtles observed within variable-length strip transects that were 3.5 m wide (i.e., turtles outside 3.5 m were ignored in this analysis).

Port	Estimated Turtles per 100 hectares (1 km^2)					Total Transect Area (hectares)
	Caretta caretta	*Chelonia mydas*	*Eretmochelys imbricata*	*Lepidochelys kempii*	All Species	
St Augustine	69	--	--	--	64	14.10
Cape Canaveral/Sebastian Inlet	431	47	3	--	474	29.94
Key West	--	--	--	--	--	7.90
Marco Island	50	50	--	6	106	17.97
Sarasota	14	5	5	14	38	20.78
Apalachicola	2	19	2	11	34	53.72
Pensacola	--	30	--	30	60	3.31

Table 2. Straight carapace lengths (SCL) of neonate sea turtles captured in epi-pelagic habitat off Florida (USA) between 2004 and 2008. Captured turtles are divided between small (<10 cm SCL) young of the year (YOY) and larger juveniles (10—30 cm SCL).

	Mean SCL (SD) in cm			
	Caretta caretta	*Chelonia mydas*	*Eretmochelys imbricata*	*Lepidochelys kempii*
YOY	4.76 (0.539) n=188	5.43 (0.103) n=8 **	--	--
Juvenile	*	21.5 (1.70) n=14 ***	19.5 (4.3.) n=4	24.8 (2.33) n=10 ****

* Omits one additional turtle not captured with estimated SCL=25 cm.
** Omits three additional turtles not captured with estimated SCL=5—6 cm.
*** Omits 19 additional turtles not captured with estimated SCL=15—20 cm.
**** Omits 12 additional turtles not captured with estimated SCL=20—25 cm.

Table 3. Behavior upon first observation in a sample of neonate sea turtles in epi-pelagic habitat. Behaviors defined in text are: Motionless (**1**), Breath (**2**), Slow Swim (**3**), Subsurface Swim (**4**), and Feeding in or Manipulating *Sargassum* (**5**). Percent occurrence was calculated on the frequency of observations for each of the four species of sea turtles. Percent turtles is divided between three observed distances between turtles and the closest floating object: touching (0 m), near (0—1 m), and distant (> 1 m). Observations were made in epi-pelagic habitat off Florida (USA) between 2004 and 2008.

% Turtles by Species and Proximity to Floating Material

	Caretta caretta (n=182)			*Chelonia mydas* (n=38)			*Eretmochelys imbricata* (n=4)			*Lepidochelys kempii* (n=20)		
Behavior	0 m	0—1 m	>1 m	0 m	0—1 m	>1 m	0 m	0—1 m	>1 m	0 m	0—1 m	>1 m
1	50.5	5.5	1.1	28.9	0	0	50.0	25.0	0	30.0	5.0	0
2	2.2	2.7	0.5	5.3	2.6	0	0	0	0	0	0	0
3	24.7	2.2	0	7.9	10.5	5.3	0	0	0	5.0	10.0	5.0
4	7.7	0.5	0	5.3	13.2	0	25.0	0	0	0.0	0.0	0
5	1.1	0	0	21.1	0	0	0	0	0	15.0	25.0	0

Table 4. Frequency of occurrence for items found in the gut contents of 203 post-hatchling sea turtles stranded dead following storm events on Florida's Atlantic coast between 1996 and 2007. Each table entry is the proportion of turtles having the specific item in their gastrointestinal tract. Because turtles typically had more than one item in their gut, proportions do not add to 100%.

	***Caretta caretta* (% of n=133)**	***Chelonia mydas* (% of n=70)**
Debris Total	**87.2**	**59.0**
Synthetic Total	**87.2**	**59.0**
Plastic Total	**86.5**	**57.0**
Hard Plastic		
White	72.2	14.3
Clear	33.8	10.5
Blue	22.6	3.8
Red	16.5	5.3
Black	9.8	0.0
Pink	9.0	1.5
Green	8.3	3.0
Purple	5.3	0.8
Tan	5.3	1.5
Gray	5.3	0.0
Other	3.8	0.0
Orange	3.8	1.5
Yellow	1.5	0.0
Brown	1.5	1.5
Soft Plastic		
Clear	54.9	31.6
White	53.4	30.8
Black	30.8	15.8
Blue	15.8	9.0
Gray	11.3	3.0
Green	11.3	1.5
Silver	8.3	0.8
Red	6.8	1.5
Purple	4.5	0.0
Other	3.0	0.8
Yellow	2.3	2.3
Orange	1.5	1.5
Pink	0.8	0.8
Brown	0.8	0.0

	Fibrous Plastic		
	Clear	19.5	10.5
	Black	12.8	3.0
	White	8.3	4.5
	Blue	6.8	3.0
	Yellow	6.0	6.8
	Red	6.0	3.0
	Green	4.5	4.5
	Pink	1.5	0.0
	Purple	1.5	0.8
Tar		52.6	26.3
Latex Total		**27.1**	**12.9**
	Black	14.3	2.3
	Blue	6.8	1.5
	Orange	6.0	0.8
	Red	6.0	1.5
	Pink	2.3	0.0
	Yellow	0.8	0.8
	White	0.8	0.8
Polystyrene Foam			
	White	7.5	2.3
Paraffin			
	White	9.0	3.0
Synthetic Fibers			
	White	1.5	0.0
	Brown	0.8	0.0
Non-synthetic Total		**24.8**	**11.4**
Mineral Materials			
	Pumice	0.8	0.0
	Charcoal	24.1	6.8
Plant Total		**99.7**	**92.9**
Sargassum		90.2	41.4
Seagrasses			
	Thalassia	45.9	28.6
	Syringodium	60.2	25.6
	Rhizome	9.0	6.8
Seed		15.8	3.8
Woody Material		42.9	6.0
Unknown Plant Tissue		34.6	6.8

Animal Total	**99.2**	**100.0**
Nematoda		
Unknown	14.3	3.8
Coelenterata		
Hydroids	58.6	33.1
Mollusca		
Bivalves	12.0	0.8
Gastropods	14.3	0.8
Unknown	4.5	1.5
Annelida		
Polychaetes	0.8	0.0
Arthropoda		
Insects	46.6	14.3
Crustaceans		
Copepods	2.3	0.0
Isopods	0.8	0.0
Decapods	9.8	4.5
Unknown	6.0	0.8
Chordata		
Fish (bone, scale)	13.5	2.3
Bird (feather)	24.1	8.3
Unknown Animal Tissue	100.0	52.6

Table 5. Dry weight (mean ± SD) and proportion of plastics in gut contents of post-hatchling sea turtles stranded dead following storm events on Florida's Atlantic coast in 2005 and 2007. Turtles were from a sub-sample stranded in Brevard and Volusia County given a complete inventory of gut contents. In this sub-sample, 94 of 94 loggerheads had plastics in their gut contents, and 65 of 94 had tar in their gut contents. For green turtles, 71 of 87 had plastics in their gut contents, 45 of 87 had tar in their gut contents, and 12 of 87 had no plastics or tar.

	Loggerheads (n=94)	Green Turtles (n=87)
Dry Wt. Total Gut Contents (mg)	205 ± 127	45.7 ± 47.0
Dry Wt. Plastics and Tar (mg)	63.0 ± 57.9	24.3 ± 27.7
% Plastics and Tar	28.6 ± 17.7	46.1 ± 55.2