Sea Turtle Strandings and Shrimp Fishing Effort in the Northwestern Gulf of Mexico, 1986-89

Charles W. Caillouet Jr.
Marcel J. Duronslet
Galveston Laboratory, Southeast Fisheries Science Center
National Marine Fisheries Service, NOAA, Galveston, Texas 77551-5997

Andre M. Landry Jr.
Department of Marine Biology, Texas A&M University
Mitchell Campus, Pelican Island, Galveston, Texas 77553

Dickie B. Revera
Galveston Laboratory, Southeast Fisheries Science Center
National Marine Fisheries Service, NOAA, Galveston, Texas 77551-5997

Donna J. Shaver
Padre Island National Seashore, National Park Service, U.S. Department of Interior
9405 South Padre Island Drive, Corpus Christi, Texas 78418

Kerry M. Stanley
Robert W. Heinly
Erich K. Stabenau
Galveston Laboratory, Southeast Fisheries Science Center
National Marine Fisheries Service, NOAA, Galveston, Texas 77551-5997

Incidental capture of sea turtles in shrimp trawls is the most important human cause of sea turtle mortality (Magnuson et al. 1990). Offshore stocks of penaeid shrimp were discovered in the Gulf of Mexico in the mid-1930s, and expansion of the offshore shrimp fishery began in the late 1940s following World War II (Whitaker 1973, Krauthamer et al. 1984, Tetty and Griffin 1984, Rayburn 1989). The industry continued to expand and improve its fishing technology into the 1980s. During the same period when shrimping effort was increasing and harvesting technology was improving, the abundance of sea turtles declined (Magnuson et al. 1990).

Sea turtle strandings along coastal shorelines of the southeastern United States have been used as one index of mortality due to shrimping (Magnuson et al. 1990). An increase in sea turtle strandings during commercial penaeid shrimp fishing seasons and a decrease with the closing of these seasons have been observed on the Atlantic coast of the southeastern United States (Hillestad et al. 1978, Talbert et al. 1980, Ruckdeschel and Zug 1982, Booker and Ehrhart 1989, Schroeder and Maley 1989). The relationship between sea turtle strandings and shrimp fishing in the northwestern Gulf of Mexico has received less attention (Rabalais and Rabalais 1980, Amos 1989, Whistler 1989, Magnuson et al. 1990), although Texas and Louisiana together produce most (almost 74% during 1986–89) of the offshore (seaward of barrier islands) commercial catch of penaeid shrimp in the southeastern United States. In this study, we used product-moment correlation analysis to test the null hypothesis that there was no relationship between monthly sea turtle strandings and shrimp fishing effort in the northwestern Gulf of Mexico coast during 1986–89.

Sea turtles would not be captured in shrimp trawls if the temporal-spatial distributions of sea turtles and shrimp fishing effort did not overlap to some extent. However, we have no a priori reason to expect that temporal-spatial distributions of sea turtles and shrimp fishing effort match exactly. Shrimp trawling in the northwestern Gulf varies seasonally and spatially as related to the annual cycle of occurrence and abundance of short-lived penaeid shrimp (Kutkuhn 1962, Neal and Maris 1985). It is most intense during spring and summer when surface waters are warm. Shrimp spawn in the Gulf where the eggs hatch and larvae develop as they are carried toward the estuaries in spring and early summer. As postlarvae, shrimp enter the estuarine nursery areas where they grow for several months before emigrating to the Gulf and becoming vulnerable to the offshore shrimp fishery. There they continue to grow and migrate to deeper waters to spawn while being exploited by the fishery. In contrast, sea turtles are long-lived and can be exposed to mortality risks for decades. Based on strandings, commercial and recreational fishing bycatch, and aerial surveys, sea turtles are most abundant in the northwestern Gulf during spring or early summer, with a lesser peak in abundance in autumn (Hildebrand 1982, Fritts et al. 1983, Thompson 1988, Magnuson et al. 1990). Waters of the northwestern Gulf are foraging habitat for the turtles, and they are used as migratory routes when the turtles move northward in spring and southward in autumn (Hildebrand 1982, 1983). The most numerous species in the

Manuscript accepted 23 August 1991.
Fishery Bulletin, U.S. 89:712–718 (1991).

northwestern Gulf are the loggerhead *Caretta caretta* and Kemp's Ridley *Lepidochelys kempi* (Rabalais and Rabalais 1980, Thompson 1988, Amos 1989, Whistler 1989).

This study deals with monthly sea turtle strandings along shorelines and shrimp fishing effort seaward of shorelines in the northwestern Gulf. Strandings are observed for the most part on barrier beaches, so they can be summarized in linear distance units of shoreline. Shrimp fishing effort is reported as days fished within spatial units represented by shrimp statistical subareas and 5-fathom (fm, 9.1 m) depth intervals (Kutkuhn 1962, Patella 1975). To test the null hypothesis, we paired monthly strandings along segments of shoreline with monthly shrimping effort within 5-fm depth intervals in the adjacent offshore waters. This was done because it was expected that the farther offshore the shrimping took place, the less likely sea turtles impacted by such shrimping would reach the shoreline, due to combined effects of surface currents, winds, waves, tides, action by scavengers (e.g., sharks) and decomposition of turtle carcasses (Heinly et al. 1988, Murphy and Hopkins-Murphy 1989, Shoop and Ruckdeschel 1989, Whistler 1989). Also, it is possible that temporal-spatial distributions of sea turtles and shrimp fishing activities overlap only within certain depth intervals (Magnuson et al. 1990).

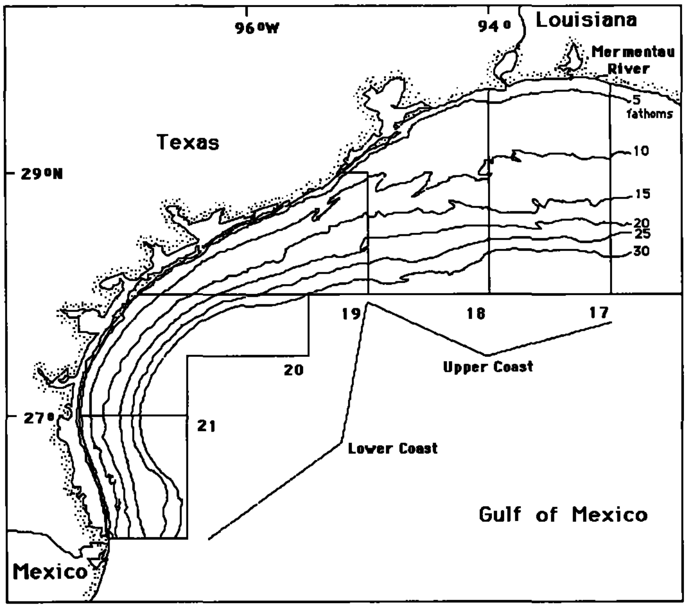

Figure 1

Boundaries of upper coast (shrimp statistical subareas 17–18) and lower coast (subareas 19–21) and 5 fm (9.1 m) depth intervals of the northwestern Gulf of Mexico (see Kutkuhn 1962, Patella 1975).

Materials and methods

Since 1980, sea turtle strandings along the coasts of the southeastern United States have been compiled by the Sea Turtle Stranding and Salvage Network (STSSN, Schroeder 1989). Shrimp fishing effort statistics in the Gulf have been compiled since 1956 (Kutkuhn 1962). Our analyses were based on data from 1986–89, including sea turtle strandings available from the STSSN database at the National Marine Fisheries Service's (NMFS) laboratory in Miami, Florida, and shrimp-fishing effort data available from the NMFS laboratory in Galveston, Texas.

Schroeder (1989) described the STSSN and procedures used to document sea turtle strandings. State coordinators review and verify the stranding data submitted by network participants, then forward them to the NMFS laboratory in Miami, Florida, where the database is maintained. The database is not independent of the distribution of human-induced mortality factors, temporal-spatial coverage is rarely uniform, and most beaches are surveyed by volunteers (Magnuson et al. 1990). To improve temporal-spatial coverage and supplement voluntary coverage, the NMFS Galveston Laboratory initiated year-round surveys along the coasts of southwestern Louisiana and Texas in 1986 (Heinly et al. 1988). Four-wheel-drive trucks, off-road motor cycles, or all-terrain vehicles were used to survey accessible gulfside shorelines at least once per month, from the Mermentau River, Louisiana, to the Texas–Mexico border (Fig. 1). The National Park Service surveyed the Padre Island National Seashore near Port Aransas, Texas, and the U.S. Fish and Wildlife Service and Texas Parks and Wildlife Department assisted in surveying Matagorda I. near Port O'Connor, Texas. Reconnaissance flights conducted at least once monthly were used to search for stranded turtles on San Jose I. near Corpus Christi, Texas.

For our analyses, sea turtle strandings (all species combined) in the northwestern Gulf of Mexico during 1986–89 were extracted from the STSSN database. Records of turtles caught by various commercial and recreational fishing methods were deleted. Also deleted were strandings of head-started (captive-reared) sea turtles, because their distribution is influenced to some extent by where they are released (Manzella et al. 1988, Fontaine et al. 1989).

The monthly sea turtle strandings and shrimp fishing effort were separated into two geographic zones: the upper coast (subareas 17–18) and lower coast (subareas 19–21). This was done because the upper coast has a wider continental shelf than the lower, so the distance a dead, sick, or injured sea turtle would have to travel from a particular depth interval to the shore is greater on the upper coast than on the lower (Fig. 1). Due to difficulty of access, the small portion of subarea 17 east of the Mermentau River in southwestern Louisiana was not surveyed for strandings, so approximately 86% of the coastline of the upper coast zone was surveyed for turtle strandings (Table 1). For this reason, we included in the upper coast zone only those turtle strandings that occurred west of the Mermentau River. We could not place a similar boundary restriction on the fishing effort data, so the eastern boundary of subarea 17 marked the eastern boundary of the upper coast in this regard. However, strandings and fishing effort were standardized to strandings per linear distance of shoreline and to days fished per unit area, respectively, so the exclusion of strandings east of the Mermentau River should have had little if any effect on our results.

Our analyses included fishing effort from the six 5-fm intervals between 0 and 30 fm (54.9 m) in shrimp statistical subareas 17–21. We did not include effort data beyond 30 fm, because only 6% of the shrimping effort on the upper coast and 8% on the lower coast occurred seaward of 30 fm during 1986–89 (Table 2).

Table 1

Extent of accessible shoreline surveyed for sea turtle strandings during 1986–89 compared with total shoreline within the upper and lower coasts of northwestern Gulf of Mexico[1].

		Shoreline		
Zone	Shrimp statistical subarea[2]	Accessible (km)	Total (km)	Percent of total
Upper coast	[3]17–18	212	245	86.5
Lower coast	19–21	408	420	97.1
Total	[3]17–21	620	665	93.2

---

[1] Derived from measurements made using dividers on National Ocean Service (NOAA) nautical charts.

[2] Figure 1; see also Kutkuhn (1962).

[3] Only the accessible shoreline west of the Mermentau River, Louisiana, was surveyed for strandings in subarea 17.

Table 2

Distribution of shrimp fishing effort on the upper and lower coasts of northwestern Gulf of Mexico by depth, 1986–89.[1]

Depth		Percent of shrimp fishing effort	
fm	m	Upper coast[2]	Lower coast[3]
0–5	0.0–9.1	28	5
5–10	9.1–18.3	27	13
10–15	18.3–27.4	16	20
15–20	27.4–36.6	10	26
20–25	36.6–45.7	7	18
25–30	45.7–54.9	6	10
30–50	54.9–91.4	6	8
Total		100	100

---

[1] Adapted from data provided by Frank Patella, NMFS Galveston Lab., pers. commun., June 1990.

[2] Shrimp statistical subareas 17 and 18 (Fig. 1; see also Kutkuhn 1962).

[3] Shrimp statistical subareas 19–21 (Fig. 1; see also Kutkuhn 1962).

Monthly sea turtle strandings within the upper and lower coasts were standardized by dividing them by distance of accessible shoreline (Table 1) in these two zones, respectively, to obtain the monthly turtle strandings per 100 km (S). We used the amount of surface area within shrimp statistical subareas and 5 fm depth intervals, as determined by Patella (1975), to standardize monthly fishing effort within the upper and lower coasts by depth interval. The surface area within a depth interval was usually greatest nearshore and decreased seaward in both zones (Fig. 1). For each 5-fm depth interval, monthly fishing effort in the upper and lower coast zones was divided by the surface area of the geographic unit (zone × depth interval) within which the effort occurred, to standardize effort to a measure of shrimping intensity. Standardized fishing effort per unit area (E) was expressed as days fished per 100 km^2.

Product-moment correlation analysis requires that the two variables have normal distributions. Neither standardized strandings (S) nor fishing effort (E) were normally distributed, as shown by large departures of their skewness and kurtosis coefficients from zero (Table 3). Therefore, we logarithmically transformed both variables, after adding 1 to each value of S and E (because some values were zero). The logarithmically transformed variables had skewness and kurtosis coefficients closer to zero, thus approaching normality. For each of the 12 combinations of two geographic zones and six depth intervals, product-moment correla-

Table 3

Descriptive statistics for untransformed and transformed monthly sea turtle strandings and shrimp fishing effort for the upper and lower coasts of northwestern Gulf of Mexico during 1986–89.

	Sea turtle strandings[1]		Shrimp fishing effort[2]	
	Upper coast	Lower coast	Upper coast	Lower coast
Untransformed				
n	48	48	288	288
Mean	4.16	3.18	13.26	17.82
Variance	43.15	9.15	509.35	374.03
Skewness coeff.	2.66	1.98	4.32	4.46
Kurtosis coeff.	7.60	4.50	22.37	31.84
Minimum	0.0	0.0	0.0	0.0
Maximum	31.7	14.7	170.1	197.4
Transformed[3]				
n	48	48	288	288
Mean	1.13	1.23	2.07	2.57
Variance	0.92	0.38	1.01	0.80
Skewness coeff.	0.66	0.36	0.51	-0.41
Kurtosis coeff.	-0.29	-0.05	0.23	0.44
Minimum	0.0	0.0	0.0	0.0
Maximum	3.49	2.75	5.14	5.29

[1] Per 100 km of accessible shoreline.
[2] Per 100 km^2 of surface area.
[3] To natural logarithms after addition of 1 to each observation.

tions between 48 pairs (12 months × 4 years) of ln(S+1) and ln(E+1) were determined.

Results

Scatter plots for geographic zones and depth intervals for which ln(S+1) was significantly ($P<0.05$) correlated with ln(E+1) are shown in Figure 2. On the upper coast, the three correlation coefficients, r, that differed significantly from zero were positive and occurred with fishing effort in the 0–5, 5–10, and 10–15 fm intervals. On the lower coast, r was significantly different from zero and positive only with fishing effort in the 5–10 and 10–15 fm intervals. These correlations indicated that turtle strandings increased as fishing effort increased in waters landward of 15 fm. Correlation coefficients for fishing effort in other depth intervals within the two zones did not differ significantly from zero.

The five significant correlations ($P<0.05$) were detected despite the relatively coarse temporal-spatial scale of the data sets (Fig. 2). Although they were of moderate strength, ranging from 0.327 to 0.512, even the lowest among them had a very small probability (P 0.0232) of occurring due to chance alone (Fig. 2). P was even smaller for the other four significant correlations. There was no significant ($P>0.05$) heterogeneity among the five correlation coefficients.

The means of the transformed strandings for the upper and lower coasts did not differ significantly (Table 3). However, the upper coast exhibited more months in which there were no strandings than did the lower coast (Fig. 2). The mean of transformed fishing effort on the lower coast was significantly higher than that for the upper coast, indicating a higher average fishing intensity on the lower than upper coast in waters landward of 30 fm.

Loggerheads and Kemp's Ridleys occurred most frequently in the strandings, followed by hawksbills *Eretmochelys imbricata*, greens *Chelonia mydas*, and leatherbacks *Dermochelys coriacea* (Table 4). Turtle strandings occurred year-round with peaks in April and May, and with a secondary peak in August. Annual strandings declined over the years covered by the study, with 417, 259, 188, and 183 strandings reported in 1986–89, respectively.

Discussion

The distributions of sea turtles and shrimp trawling must overlap to some degree because it is well documented that sea turtles are caught in shrimp trawls

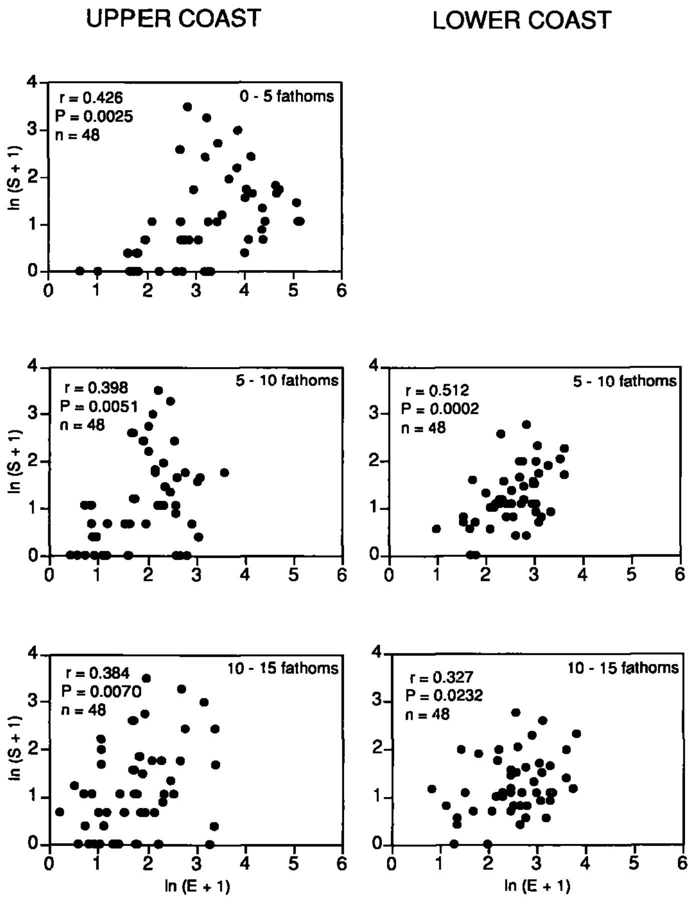

Figure 2

Scatter plots for significant ($P<0.05$) correlations between transformed monthly sea turtle strandings, ln(S + 1), and transformed monthly shrimp fishing effort, ln(E + 1), on upper coast (shrimp statistical subareas 17–18) and lower coast (subareas 19–21) of the northwestern Gulf of Mexico during 1986–89.

(Murphy and Hopkins-Murphy 1989, Magnuson et al. 1990). In fact, sea turtles may congregate in shrimping areas to feed on discarded bycatch (Shoop and Ruckdeschel 1982, Ruckdeschel and Shoop 1988). However, no cause-and-effect relationship between sea turtle strandings and shrimping has been demonstrated to date.

It is noteworthy that our analyses detected significant correlations despite the wide variation inherent in turtle stranding and fishing effort data. These significant positive correlations are circumstantial evidence of a linkage between strandings and shrimping, but do not demonstrate that the strandings were caused by shrimping. Strandings and shrimping occur year-round and both are strongly seasonal, with peaks during warm months. The correlations we detected are consistent with earlier findings that incidental capture in shrimp trawls is the major cause of sea turtle mortality associated with human activities, but it is also recognized that other fisheries, dredging, collisions with boats, oil-rig removal with underwater explosives, entrainment in power plants, and directed take contribute to sea turtle mortality at sea (Magnuson et al. 1990).

Interpretation of statistical relationships between sea turtle strandings and shrimp trawling activity is confounded by the dynamics of waterborne transport of stressed, injured, or dead turtles to stranding sites. Surface currents, winds, waves, tides, and scavengers, as well as conditions affecting the buoyancy of turtles, can affect their transport toward or away from shore (Murphy and

Table 4

Species composition of sea turtle strandings in the northwestern Gulf of Mexico by month, summed over years 1986–89.

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Loggerhead *Caretta caretta*	9	10	46	146	95	33	40	37	31	29	19	20	515
Kemp's Ridley *Lepidochelys kempi*	0	6	36	82	48	36	27	51	23	22	17	9	357
Hawksbill *Eretmochelys imbricata*	0	1	2	0	1	5	4	15	18	14	2	5	67
Green *Chelonia mydas*	1	0	5	7	6	6	2	2	0	4	1	4	38
Leatherback *Dermochelys coriacea*	0	0	1	8	5	3	0	1	0	2	3	0	23
Undetermined	0	0	6	6	2	5	10	4	5	6	1	2	47
Total	10	17	96	249	157	88	83	115	77	78	43	40	1047

Hopkins-Murphy 1989, Shoop and Ruckdeschel 1989, Whistler 1989). In the northwestern Gulf, tidal currents move water toward shore, and waves and surface drift transport floating objects to the beach from longshore currents (Collard 1990, Collard and Ogren 1990). Swimming and diving abilities may be reduced in stressed or injured sea turtles, causing them to remain at or near the surface while being transported more or less passively. The longer a carcass remains in the water, the longer it would be subjected both to decomposition and scavengers which could cause it to disarticulate, release bloating gases, and sink. Not all turtles that become stranded are documented by the STSSN. Thus, reported strandings of sea turtles provide an incomplete measure of those that are killed or injured by humans or that succumb to natural mortality factors at sea (Murphy and Hopkins-Murphy 1989).

On the upper coast, significant correlations were observed in 0–15fm where 71% of the shrimp fishing effort on the upper coast occurred during 1986–89 (Table 2, Fig. 2). Significant correlations were observed on the lower coast in 5–15fm where 33% of the lower coast effort occurred. Such correlations suggest that the impact of shrimping on sea turtles may occur within 15fm seaward of the coastline, and this is consistent with the conclusion by Magnuson et al. (1990) that incidental capture of sea turtles in shrimp trawls occurs for the most part in depths up to 27m (15fm). However, on the lower coast 5% of the shrimp fishing effort occurred in the 0–5fm interval, and we observed no significant correlation for that interval.

It is neither practical nor cost-effective to attempt characterization of all conditions and factors that influence whether sea turtles become stranded and where and when they become stranded in relation to various causes of mortality, injury, stress, or illness at sea. However, year-round coverage is essential to monitoring temporal variations, and it provides biological samples, specimens for necropsy, and other information that can be compared with human activities and oceanographic variables in examining the causes of strandings.

Acknowledgments

Special thanks are due all who participated in documenting sea turtle strandings in southwestern Louisiana and Texas. Sea turtle stranding data were provided from the STSSN database by Dr. Nancy Thompson and Wendy Teas, NMFS Miami Laboratory, Miami, Florida. Shrimp-fishing effort data were provided by Frank Patella, NMFS Galveston Laboratory, Galveston, Texas.

Drs. Edward Klima, Terry Henwood, Nat Frazer, James Nance, Larry Ogren, and Tom Minello as well as Anthony Amos, Clark Fontaine, Sally Hopkins-Murphy, Sharon Manzella, and Zoula Zein-Eldin reviewed the manuscript and provided helpful comments. The United States Army Corps of Engineers, Galveston District, Galveston, Texas, provided overwater transportation to west Matagorda Peninsula. Texas Parks and Wildlife Department provided overwater transportation to Matagorda I. Reconnaissance flights were made possible by the U.S. Coast Guard, Perry R. Bass, San Jose Island Cattle Company, and Major Donald C. Meek. Robert Caplinger typed the manuscript. Jo Anne Williams and Sharon Manzella prepared the figures.

Citations

Amos, A.F.
1989 Recent strandings of sea turtles, cetaceans and birds in the vicinity of Mustang Island, Texas. *In* Caillouet, C.W. Jr., and A.M. Landry Jr. (eds.), Proceedings, First international symposium on Kemp's Ridley sea turtle biology, conservation and management, p. 51. TAMU-SG-89-105 (abstr. only), Texas A&M Univ. Sea Grant Coll. Prog., College Station.

Booker, W.C., and L.M. Ehrhart
1989 Aerial surveys of marine turtle carcasses in National Marine Fisheries Service statistical zones 28 and 29; 11 August 1987 to 31 December 1988. *In* Eckert, S.A., K.L. Eckert, and T.H. Richardson (compilers), Proceedings, Ninth annual workshop on sea turtle conservation and biology, p. 15–17. NOAA Tech. Memo. NMFS-SEFC-232, Southeast Fish. Sci. Cent., Miami.

Collard, S.B.
1990 Guest editorial: Speculation on the distribution of oceanic-stage sea turtles, with emphasis on Kemp's Ridley in the Gulf of Mexico. Marine Turtle Newsl. 48:6–8.

Collard, S.B., and L.H. Ogren
1990 Dispersal scenarios for pelagic post-hatchling sea turtles. Bull. Mar. Sci. 47(1):464–491.

Fontaine, C.T., S.A. Manzella, T.D. Williams, R.M. Harris, and W.J. Browning
1989 Distribution, growth and survival of head started, tagged and released Kemp's Ridley sea turtles (*Lepidochelys kempi*) from year-classes 1978–1983. *In* Caillouet, C.W. Jr., and A.M. Landry Jr. (eds.), Proceedings, First international symposium on Kemp's Ridley sea turtle biology, conservation and management, p. 124–144. TAMU-SG-89-105, Texas A&M Univ. Sea Grant Coll. Prog., College Station.

Fritts, T.H., A.B. Irvine, R.D. Jennings, L.A. Collum, W. Hoffman, and M.A. McGehee
1983 Turtles, birds, and mammals in the northern Gulf of Mexico and nearby Atlantic waters. U.S. Fish Wildl. Serv. FWS/OBS-82/65, 455 p.

Heinly, R.W., E.K. Stabenau, A.M. Landry, and M. Duronslet
1988 Mutilation of stranded sea turtles along the Texas coast. *In* Schroeder, B.A. (compiler), Proceedings, Eighth annual workshop on sea turtle conservation and biology, p. 33–34. NOAA Tech. Memo. NMFS-SEFC-214, Southeast Fish. Sci. Cent., Miami.

Hildebrand, H.H.
1982 A historical review of the status of sea turtle populations in the western Gulf of Mexico. *In* Bjorndal, K.A. (ed.), Biology and conservation of sea turtles, p. 447–453. Smithson. Inst. Press, Wash. DC.

Hildebrand, H.
1983 Random notes on sea turtles in the western Gulf of Mexico. *In* Owens, D., D. Crowell, G. Dienberg, M. Grassman, S. McCain, Y. Morris, N. Schwantes, and T. Wibbels (eds.), Western Gulf of Mexico sea turtle workshop proceedings, p. 34-41. TAMU-SG-84-105, Texas A&M Univ. Sea Grant Coll. Prog., College Station.

Hillestad, H.O., J.I. Richardson, and G.K. Williamson
1978 Incidental capture of sea turtles by shrimp trawlermen in Georgia. *In* Proceedings, Annual conference, Southeast. Assoc. Fish and Wildlife Agencies 32:167–178.

Krauthamer, J.T., W.E. Grant, and W.L. Griffin
1984 Characteristics of the Texas shrimp fleet, 1979–82. Mar. Fish. Rev. 46(2):53–59.

Kutkuhn, J.H.
1962 Gulf of Mexico commercial shrimp populations—trends and characteristics, 1956–59. Fish. Bull., U.S. 62:343–402.

Magnuson, J.J., K.A. Bjorndal, W.D. DuPaul, G.L. Graham, D.W. Owens, C.H. Peterson, P.C.H. Pritchard, J.I. Richardson, G.E. Saul, and C.W. West
1990 Decline of the sea turtles: Causes and prevention. Natl. Research Council, Natl. Acad. Sci. Press, Wash. DC, 190 p.

Manzella, S.A., C.W. Caillouet Jr., and C.T. Fontaine
1988 Kemp's Ridley, *Lepidochelys kempi*, sea turtle head start tag recoveries: Distribution, habitat, and method of recovery. Mar. Fish. Rev. 50(3):24–32.

Murphy, T.M., and S.R. Hopkins-Murphy
1989 Sea turtle and shrimp fishing interactions: A summary and critique of relevant information. Center for Marine Conservation, Wash. DC, 52 p.

Neal, R.A., and R.C. Maris
1985 Fisheries biology of shrimps and shrimplike animals. *In* Provenzano, A.J. Jr. (ed.), Economic aspects: Fisheries and culture, The biology of crustacea, p. 1–110. Academic Press, NY, 331 p.

Patella, F.
1975 Water surface area within statistical subareas used in reporting Gulf Coast shrimp data. Mar. Fish. Rev. 37(12): 22–24.

Rabalais, S.C., and N.N. Rabalais
1980 The occurrence of sea turtles on the south Texas coast. Contrib. Mar. Sci. 23:123–129.

Rayburn, R.
1989 Fishing industry perspective on conservation and management of sea turtles. *In* Caillouet, C.W. Jr., and A.M. Landry Jr. (eds.), Proceedings, First international symposium on Kemp's Ridley sea turtle biology, conservation and management, p. 27–29. TAMU-SG-89-105, Texas A&M Univ. Sea Grant Coll. Prog., College Station.

Ruckdeschel, C., and C.R. Shoop
1988 Gut contents of loggerheads: Findings, problems and new questions. *In* Schroeder, B.A. (compiler), Proceedings, Eighth annual workshop on sea turtle conservation and biology, p. 97–98. NOAA Tech. Memo. NMFS-SEFC-214, Southeast Fish. Sci. Cent., Miami.

Ruckdeschel, C., and G.R. Zug
1982 Mortality of sea turtles *Caretta caretta* in coastal waters of Georgia. Biol. Conserv. 22(1982):5–9.

Schroeder, B.A.
1989 Marine turtle data base management: National Marine Fisheries Service—Miami Laboratory. *In* Caillouet, C.W. Jr., and A.M. Landry Jr. (eds.), Proceedings, First international symposium on Kemp's Ridley sea turtle biology, conservation and management, p. 153–156. TAMU-SG-89-105, Texas A&M Univ. Sea Grant Coll. Prog., College Station.

Schroeder, B.A., and C.A. Maley
1989 1988 fall/winter strandings of marine turtles along the northeast Florida and Georgia coasts. *In* Eckert, S.A., K.L. Eckert, and T.H. Richardson (compilers), Proceedings, Ninth annual workshop on sea turtle conservation and biology, p. 159–161. NOAA Tech. Memo. NMFS-SEFC-232, Southeast Fish. Sci. Cent., Miami.

Shoop, C.R., and C. Ruckdeschel
1982 Increasing turtle strandings in the southeast United States: A complicating factor. Biol. Conserv. 23(1982): 213–215.
1989 Trauma to stranded sea turtles on Cumberland Island, Georgia, during 1986 and 1987. *In* Eckert, S.A., K.L. Eckert, and T.H. Richardson (compilers), Proceedings, Ninth annual workshop on sea turtle conservation and biology, p. 169–170. NOAA Tech. Memo. NMFS-SEFC-232, Southeast Fish. Sci. Cent., Miami.

Talbert, O.R. Jr., S.E. Stancyk, J.M. Dean, and J.M. Will
1980 Nesting activity of the loggerhead turtle *Caretta caretta* in South Carolina I: A rookery in transition. Copeia 1980(4): 709–718.

Tetty, E.O., and W.L. Griffin
1984 Investment in Gulf of Mexico shrimp vessels, 1965–77. Mar. Fish. Rev. 46(2):49–52.

Thompson, N.B.
1988 The status of loggerhead, *Caretta caretta*; Kemp's Ridley, *Lepidochelys kempi*; and green, *Chelonia mydas*, sea turtles in U.S. waters. Mar. Fish. Rev. 50(3):16–23.

Whistler, R.G.
1989. Kemp's Ridley sea turtle strandings along the Texas coast, 1983–1985. *In* Caillouet, C.W. Jr., and A.M. Landry Jr. (eds.), Proceedings, First international symposium on Kemp's Ridley sea turtle biology, conservation and management, p. 43–50. TAMU-SG-89-105, Texas A&M Univ. Sea Grant Coll. Prog., College Station.

Whitaker, D.R.
1973 The U.S. shrimp industry: Past trends and prospects for the 1970's. Mar. Fish. Rev. 35(5-6):23–30.