Spatial and Temporal Distribution of Sea Turtles in the Western North Atlantic and the U.S. Gulf of Mexico from Marine Recreational Fishery Statistics Survey (MRFSS)

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Introduction

Limited data exist on sea turtle (Cheloniidae and Dermochelydae) distributions and seasonal patterns of movement, knowledge which can aid conservation managers in their efforts to protect sea turtles from potentially harmful human interaction (National Research Council, 1990). Systematic surveys (aerial, shipboard, strandings), in addition to opportunistic sightings by fishery observers and the general public, have been used to gather these important distributional data.

Since large areas can be covered in a relatively short time frame, aerial surveys are widely used (National Research Council, 1990; Henwood and Epperly, 1999). Although not as widely used, shipboard surveys also have been employed to obtain sea turtle seasonal distributions in areas up to 50 miles offshore (Lee and Palmer, 1981; Shoop and Kenney, 1992). Since 1980, the NOAA, National Marine Fisheries Service (NMFS), Sea Turtle Stranding and Salvage Network (STSSN) has been documenting the strandings of sea turtles along the U.S. Gulf of Mexico and Atlantic coasts (Schroeder, 1989) which can provide some insight into the spatial and temporal patterns of sea turtle distribution.

Sea turtle distribution also can be obtained through opportunistic observations of sea turtles. Recaptures of tagged turtles can provide valuable data on migration and seasonal distribution patterns (Henwood, 1987; Henwood and Ogren, 1987). Observers on commercial fishing vessels record position data for sea turtles incidentally captured in fishing gear, as well as for opportunistic ocean sightings (Henwood, 1987; Henwood and Ogren, 1987). Surveys of people likely to encounter sea turtles (recreational anglers and boaters, commercial fishermen) likewise have provided useful information regarding the distribution and movements of sea turtles (Carr et al., 1982; Epperly et al., 1995b).

Another potential source of such data is the NMFS Marine Recreational Fishery Statistics Survey (MRFSS) (http://www.st.nmfs.gov/st1/recreational/). In 1979, the NMFS initiated the MRFSS to estimate the impact of marine recreational fishing on marine resources along the Atlantic and Gulf of Mexico coasts of the United States (Essig and Holliday, 1991). Recreational fishing activity data are collected by interviewing a sample of recreational anglers fishing in coastal and ocean waters throughout the United States, with the exception of Texas which conducts a comparable, but separate, survey.

In 1991 and 1992, the MRFSS provided synoptic data on the spatio-temporal distribution of sea turtles by asking recreational anglers if they had observed a sea turtle on their fishing trip. This was the first such source of information covering the entire U.S. Atlantic and Gulf of Mexico coasts simultaneously. From those reported observations, we describe relative changes in seasonal abundance of sea turtles along both coasts.

Methods

The MRFSS utilizes, in part, interviews of anglers at fishing access sites as they return from their fishing trips (Essig

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ABSTRACT—Systematic surveys, along with opportunistic sightings, have provided important information on sea turtle (Cheloniidae and Dermochelydae) distributions, knowledge which can help reduce the risk of harmful human interaction. In 1991 and 1992, the Marine Recreational Fishery Statistics Survey (MRFSS) of the National Marine Fisheries Service, NOAA, provided a unique opportunity to gain additional, synoptic information on the spatial and temporal distribution of sea turtles along the U.S. Atlantic and Gulf of Mexico coasts by asking recreational anglers if they had observed a sea turtle on their fishing trip. During the spring and summer months of those years, as water temperatures warmed, the MRFSS documented an increase in sea turtle sightings in inshore waters and in a northward direction along the U.S. Atlantic Coast and in a westward direction along the northern Gulf of Mexico. This pattern reversed in the late summer and fall months as water temperatures cooled, with sea turtles concentrating along Georgia and both coasts of Florida. Although the MRFSS did not provide species or size composition of sea turtles sighted, and effort varied depending upon location of fishing activity and time of year anglers were queried, it did provide an additional and useful means of ascertaining spatial and temporal distributions of sea turtles along these coasts.

and Holliday, 1991). Intercept interviews are used to collect catch and demographic data from anglers who have just completed a fishing trip from different modes of fishing: a charter/headboat, a private/rental boat, or from shore (pier, beaches, banks). As anglers complete their fishing trip they are asked to name the body of water in which they conducted most of their fishing activity and the number of hours that they fished. Bays, inlets, rivers, and sounds are scored as inshore waters. If they fished in the ocean, they are asked if they fished within (nearshore) or beyond (offshore) 5.6 km of shore.

Sampling effort along the gulf coast of Florida included inshore and offshore areas only. Sampling was conducted all days of the week, but most (75%) of the effort was on weekends and holidays. Due to low fishing effort, sampling was not conducted during January–February on the Atlantic coast north of Florida (except for North Carolina), and November–December for New Hampshire and Maine.

Sampling is stratified by state, mode of fishing, and wave (2-month sampling period) each year with a minimum of 30 interviews in each stratum. Interview effort may exceed this minimum, based on the average estimated fishing effort of the previous 3 survey years. Survey sampling sites, although randomly selected, are weighted by expected fishing activity.

Beginning in 1989, individuals fishing in North Carolina were asked if they had sighted sea turtles during their fishing trip. They were not asked to enumerate or identify the turtles sighted, just to indicate presence or absence of sea turtle sightings during their fishing trip. Multiple anglers on the same fishing boat or individual anglers on piers or jetties might report the same turtle.

In 1991 and 1992, this question was asked in all states participating in the MRFSS, which includes all states along the Atlantic and Gulf of Mexico coasts of the United States (excluding Texas). This question was not included in surveys after 1992.

After combining the data from both years, we calculated sightings per unit of effort (SPUE) for each state by dividing the total number of turtles sighted by the total number of hours fished for each wave (bimonthly period) and in each area. Sightings from charter, private/rental, and headboats may include those turtles sighted during transit time; however, since total number of hours fished (used to calculate SPUE) does not include transit time, this may result in an overestimation of these sightings.

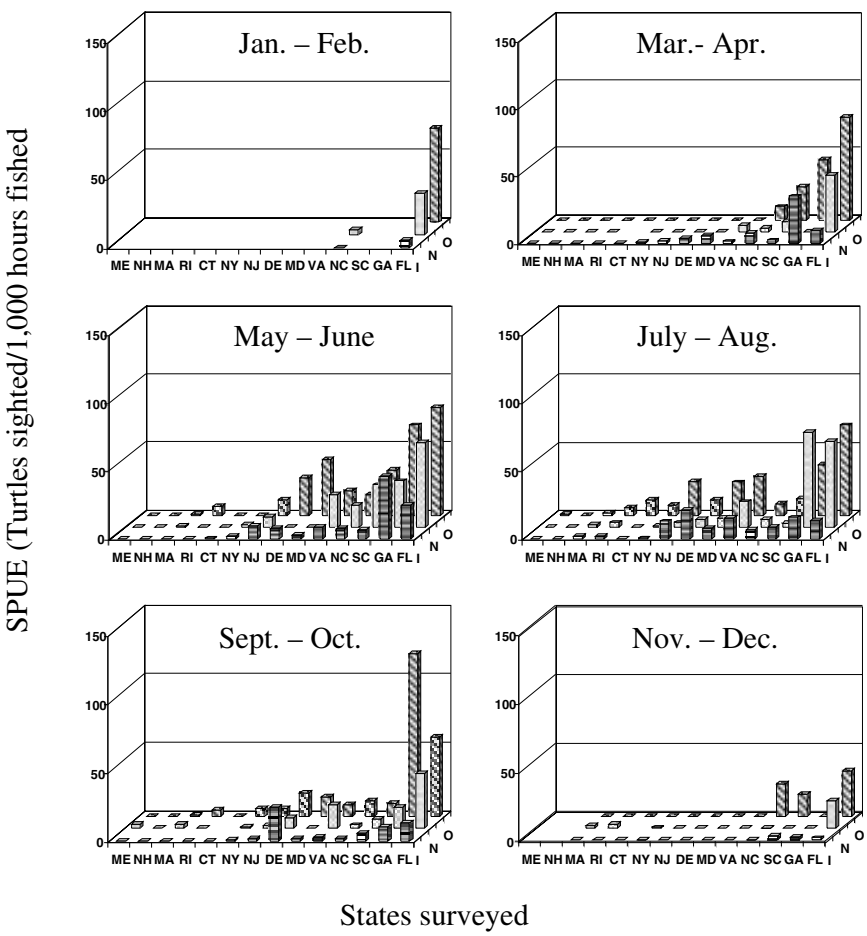

Figure 1.—Frequency distribution of sea turtles sighted by recreational anglers interviewed along the U.S. Atlantic coast during intercept interviews of the Marine Recreational Fishery Statistics Survey, 1991–92. Total number of sea turtle sightings/1,000 hours fished are given bimonthly for each state. Absence of data indicates no anglers were interviewed. I=Inshore; N=Nearshore; O=Offshore.

Results

The Marine Recreational Fishery Statistics Survey for the U.S. Atlantic and Gulf of Mexico states (excluding Texas) interviewed 74,007 anglers in 1991 and 90,596 in 1992, representing a total of about 700,000 h of fishing activity (Tables 1, 2). Of these anglers, about 4.5% reported sighting a live sea turtle while fishing.

U.S. Atlantic Sightings

January–February

During January and February, sea turtles were observed in North Carolina's nearshore waters and in Florida's nearshore and offshore waters (Table 1, Fig. 1). However, MRFSS survey effort was lacking in all other states. The sighting rates of sea turtles was greatest in the nearshore and offshore waters of Florida.

Table 1.—Effort of recreational anglers interviewed along the Atlantic Coast during intercept interviews of the Marine Recreational Fishery Statistics Survey, 1991–1992. Total number of hours fished and interviews (in parentheses) are given bimonthly for each state and area fished. Absence of data indicates no survey effort.

State	Distance from shore	Total number of hours fished (number of interviews)					
		Jan–Feb	Mar–Apr	May–Jun	Jul–Aug	Sep–Oct	Nov–Dec
Maine	Inshore		28.0 (15)	412.0 (148)	936.0 (326)	593.5 (213)	
	Nearshore		82.5 (41)	210.0 (80)	639.0 (213)	332.5 (116)	
	Offshore		469.5 (102)	832.0 (192)	1009.5 (262)	537.5 (118)	
New Hampshire	Inshore		13.0 (9)	299.5 (88)	627.5 (154)	161.0 (58)	
	Nearshore		63.5 (36)	190.0 (76)	178.0 (58)	220.5 (76)	
	Offshore		796.5 (181)	734.5 (173)	720.0 (179)	381.0 (77)	
Massachusetts	Inshore		666.5 (247)	3,632.5 (1078)	6,607.5 (1835)	5,895.5 (1567)	1,103.5 (325)
	Nearshore		361.0 (127)	4,003.5 (1223)	7,687.5 (2354)	5,373.0 (1456)	469.5 (165)
	Offshore		923.5 (213)	3,142.5 (663)	3,791.5 (943)	2,677.5 (582)	690.5 (142)
Rhode Island	Inshore		426.0 (131)	2,836.0 (870)	4,096.0 (1241)	3,841.0 (1066)	609.5 (153)
	Nearshore		81.0 (34)	559.0 (140)	2,531.0 (698)	2,297.5 (586)	723.5 (187)
	Offshore		694.0 (138)	1,089.0 (218)	2,835.0 (553)	3,043.5 (566)	1,077.0 (188)
Connecticut	Inshore		684.5 (190)	4,090.0 (1200)	7,152.0 (1918)	4,962.0 (1389)	645.5 (176)
	Nearshore			30.0 (4)	7.0 (2)		
	Offshore		278.5 (70)	424.5 (81)	455.0 (85)	353.0 (54)	28.5 (9)
New York	Inshore		6,074.5 (1459)	12,826.0 (3085)	18,838.0 (4566)	14,474.5 (3531)	3,361.0 (864)
	Nearshore		1,464.5 (309)	3,499.5 (792)	4,656.5 (1016)	5,739.0 (1241)	3,547.0 (725)
	Offshore		464.0 (81)	1,402.0 (212)	2,684.5 (419)	2,220.5 (320)	818.5 (151)
New Jersey	Inshore		1,125.5 (295)	4,784.5 (1219)	6,250.0 (1536)	6,557.0 (1785)	1,113.0 (314)
	Nearshore		163.5 (40)	3,154.5 (735)	5,186.0 (1271)	11,901.5 (2923)	4,631.0 (1094)
	Offshore		890.0 (153)	2,063.0 (498)	2,949.0 (568)	2,017.0 (370)	630.0 (131)
Delaware	Inshore		802.0 (248)	6,428.0 (1350)	10,928.0 (2396)	4,327.5 (919)	604.5 (183)
	Nearshore		46.0 (15)	235.0 (54)	552.0 (114)	489.0 (102)	311.0 (76)
	Offshore		688.5 (165)	849.5 (155)	2,065.0 (290)	532.0 (79)	250.0 (53)
Maryland	Inshore		2,016.5 (567)	5,047.5 (1269)	6,960.0 (1675)	5,467.5 (1309)	494.0 (159)
	Nearshore		39.5 (15)	96.0 (26)	158.0 (49)	105.0 (30)	163.5 (48)
	Offshore		557.5 (166)	365.5 (94)	1,037.5 (205)	287.5 (76)	285.5 (87)
Virginia	Inshore		1,502.0 (348)	5,860.5 (1225)	4,926.5 (1033)	3,935.5 (754)	1,030.5 (261)
	Nearshore		460.5 (101)	1,097.5 (243)	1,308.0 (303)	569.0 (141)	62.0 (18)
	Offshore		486.0 (111)	790.0 (164)	882.0 (167)	718.0 (107)	364.5 (72)
North Carolina	Inshore	18.5 (5)	1,098.0 (295)	6,630.5 (1601)	4,717.2 (1101)	7,450.5 (1675)	3,095.0 (699)
	Nearshore	543.0 (197)	5,938.0 (1443)	19,301.5 (4377)	17,911.8 (4163)	17,716.5 (3891)	10,285.0 (2402)
	Offshore		2,717.0 (438)	12,932.0 (2074)	12,329.0 (1953)	11,420.0 (1847)	1,726.5 (283)
South Carolina	Inshore		843.0 (218)	2,419.3 (468)	2,142.0 (461)	1,794.8 (368)	2,398.5 (502)
	Nearshore		397.8 (75)	942.5 (189)	736.5 (145)	904.5 (191)	479.5 (94)
	Offshore		728.5 (104)	1,215.5 (194)	1,587.0 (232)	1,310.0 (196)	444.5 (86)
Georgia	Inshore		2,240.5 (647)	2,375.5 (618)	1,916.5 (493)	2,428.5 (560)	2,679.5 (625)
	Nearshore		171.5 (41)	208.0 (53)	390.5 (90)	191.0 (54)	242.0 (51)
	Offshore		180.0 (38)	742.5 (144)	679.0 (129)	144.0 (30)	12.0 (2)
Florida–East Coast	Inshore	3,932.5 (1153)	4,361.0 (1353)	4,940.0 (1369)	3,243.0 (937)	3,690.0 (1026)	5,220.0 (1546)
	Nearshore	3,113.5 (810)	4,032.5 (1190)	3,511.5 (890)	5,883.0 (1584)	3,296.0 (839)	2,968.5 (791)
	Offshore	1,899 (380)	2,657.5 (597)	4,365.0 (982)	5,776.5 (1251)	2,249.0 (480)	1,252.5 (272)

March–April

During this period, MRFSS surveys were conducted from Florida to Maine. However, sighting rates were highest from the southern states (North Carolina to Florida), in particular, from Florida's nearshore and offshore waters (Table 1, Fig. 1). Sea turtles were observed in inshore waters as far north as New York, but in relatively low numbers. The most notable exception was Georgia, where the sighting rate of sea turtles in inshore waters was comparable to South Carolina, Georgia, and Florida nearshore and offshore sighting rates (Fig. 1). Although anglers from New York, New Jersey, Delaware, and Maryland only reported sea turtle sightings from inshore waters, fishing effort there was considerably higher than in the nearshore or offshore waters (Table 1).

May–June

Sea turtle sighting rates during May and June increased considerably from New Jersey to Florida with some nearshore and offshore sightings reported from as far north as Rhode Island and Massachusetts (Fig. 1). Inshore sightings had progressed north to Connecticut, but sighting rates were highest in Georgia and Florida. Nearshore sighting rates increased substantially in Virginia (from 4.3 to 23.7), North Carolina (from 2.9 to 15.6), South Carolina (from 7.5 to 30.8), and Georgia (from 0.0 to 33.7). Offshore sighting rates increased in Georgia, South Carolina, and North Carolina, and turtles were reported for the first time in Virginia, Maryland, Delaware, and New Jersey's offshore waters. It is interesting to note that Maryland's offshore sighting rates were exceeded only by Georgia's and Florida's.

July–August

With the exception of New Hampshire, sea turtles were observed from Maine to Florida during July and August and were reported from the inshore waters of Massachusetts and Rhode Island for the first time (Fig. 1). The highest sighting rate for inshore waters occurred in New Jersey, Delaware, Virginia, Georgia, and Florida; however, inshore sighting rates from Georgia and Florida decreased by

Table 2.—Effort of recreational anglers interviewed along the Gulf Coast during intercept interviews of the Marine Recreational Fishery Statistics Survey, 1991–92. Total number of hours fished and interviews (in parentheses) are given bimonthly for each state and area fished. Absence of data indicates no survey effort. Texas is not included in the survey.

State	Distance from shore	Total number of hours fished (number of interviews)					
		Jan–Feb	Mar–Apr	May–Jun	Jul–Aug	Sep–Oct	Nov–Dec
Louisiana	Inshore	2,352.0 (623)	2,990.0 (697)	4,076.0 (991)	3,255.0 (769)	4,173.0 (967)	4,929.0 (1055)
	Nearshore	854.0 (193)	1,552.5 (326)	1,794.0 (383)	3,114.5 (705)	1,427.0 (306)	452.5 (99)
	Offshore	436.5 (89)	986.0 (183)	1,179.0 (196)	1,102.5 (198)	1,311.5 (247)	258.5 (51)
Mississippi	Inshore	436.5 (160)	1,333.0 (383)	1,307.0 (296)	1,648.0 (382)	1,903.5 (455)	983.5 (258)
	Nearshore	231.0 (71)	479.5 (134)	1,271.0 (325)	534.5 (140)	802.0 (219)	715.0 (216)
	Offshore	182.5 (35)	395.0 (73)	1,136.0 (193)	2,564.5 (398)	1,850.5 (313)	413.5 (106)
Alabama	Inshore	261.0 (83)	572.5 (193)	575.5 (130)	327.5 (94)	419.5 (115)	791.0 (213)
	Nearshore	596.0 (179)	974.5 (278)	1,122.0 (275)	1,313.0 (341)	889.0 (241)	622.5 (162)
	Offshore	559.5 (150)	933.5 (228)	1,860.5 (437)	1,615.0 (345)	1,827.0 (425)	1,093.0 (286)
Florida–West Coast	Inshore	4,906.0 (1385)	5,844.5 (1577)	5,049.5 (1370)	3,183.1 (816)	5,712.5 (1501)	5,464.0 (1414)
	Nearshore						
	Offshore	5,795.5 (1304)	8,765.0 (2038)	9,045.5 (2108)	7,042.5 (1649)	8,555.5 (2019)	5,725.5 (1408)

50% or more from the previous wave (bimonthly period). Sea turtles were sighted for the first time in the nearshore waters of Rhode Island, Delaware, and Maryland. Offshore sighting rates in New Jersey, Maryland, and Virginia were only slightly lower than off Georgia.

September–October

There was a notable decrease in sea turtle sighting rates during September and October for most of the northern states (Maine to Virginia) and a shift from inshore to offshore sightings, with a few notable exceptions (Fig. 1). While most states showed a decrease in inshore sighting rates, Delaware showed an increase, surpassing all other states, despite a decrease in fishing effort. Maine, Massachusetts, New York, and Delaware had slight to moderate increases in nearshore sighting rates, but the greatest sighting rates were from Virginia southward. Finally, all states north of North Carolina showed decreases in offshore sighting rates with the exception of Delaware which showed a slight increase.

November–December

With a few exceptions, no sea turtles were sighted north of North Carolina during this period (Fig. 1). (No MRFSS survey effort was present in Maine, New Hampshire, or the nearshore waters of Connecticut.) Sea turtle sighting rates decreased in inshore and nearshore waters from North Carolina to Florida. Offshore sighting rates from North and South Carolina increased, but they decreased from Georgia and Florida; however, only two anglers fishing in Georgia's offshore waters were queried (Table 1).

U.S. Gulf of Mexico Sightings

January–February

Sea turtles were sighted only in the offshore waters of Florida and Alabama, and the inshore waters of Florida during January and February (Fig. 2). Offshore sighting rates from Florida (29.2) and Alabama (21.4) were almost ten-fold greater than Florida's inshore rates (4.7). There was no MRFSS survey effort in Florida's nearshore waters.

March–April

Sea turtles were sighted in all areas during this period except Mississippi inshore waters (Fig. 2). Sighting rates were greater in the eastern Gulf of Mexico than the western; Florida had the highest inshore sighting rates followed by Alabama. Sighting rates from Florida (28.0) and Alabama (15.0) offshore waters exceeded those from both Mississippi (10.3) and Louisiana (1.0).

May–June

Sea turtle sighting rates increased or remained comparable from previous months in all areas (Fig. 2). Offshore sighting rates from all states exceeded their nearshore and inshore sighting rates. Mississippi nearshore sighting rates (11.8) had increased nearly ten-fold from the previous months (2.1) and exceeded all other states' inshore and nearshore waters sighting rates. Sighting rates from Louisiana were less than those from any other Gulf state for all waters and remained relatively unchanged or only slightly increased from the previous months' sighting rates.

July–August

With a few exceptions, sighting rates decreased for all waters during this period (Fig. 2). Sighting rates from Florida inshore waters greatly exceeded inshore sighting rates from any other Gulf state. Alabama had a 50% reduction in its nearshore sighting rates from the previous wave while Mississippi nearshore sighting rates dropped from 11.8 to 0. Although sighting rates from Louisiana offshore waters had increased slightly from the previous wave, they were still less than 50% of the sighting rates from either Alabama or Florida offshore waters.

September–October

Sighting rates decreased again for all states in all waters with the exception of Mississippi nearshore and Louisiana and Alabama inshore waters which showed increases (Fig. 2). Interestingly, Alabama and Louisiana inshore sighting rates peaked during this time period when most of the other states and other areas were demonstrating a reduction in sea turtle sighting rates.

November–December

Sea turtles were sighted only in the offshore waters of Florida and Alabama, the inshore waters of Florida, and the nearshore waters of Mississippi during this period. These were very similar to

the sighting patterns from January and February (Fig. 2). Sighting rates from all states and all waters had decreased again in November and December with the exception of Alabama which had an increase in its offshore sighting rate.

Discussion

Atlantic

With the exception of most states during January and February, and Maine and New Hampshire in November and December, MRFSS survey effort was present along U.S. Atlantic coast states at all times for all waters. As waters warmed during the spring and early summer months (March–June), sea turtle sighting rates increased in a northward direction and into nearshore and inshore waters. This pattern was reversed during the late summer and fall months (July–October), presumably as waters cooled.

Aerial surveys conducted along the U.S. Atlantic coast from Florida to Massachusetts (Witzell and Azarovitz, 1996), as well as those conducted along the northeastern (Shoop and Kenney, 1992) and southeastern United States (Thompson and Huang, 1993; Musick et al., 1994; Thompson[1]), revealed a similar pattern of movement. Sighting densities increased during the spring and summer months (Shoop and Kenney, 1992; Thompson and Huang, 1993; Witzell and Azarovitz, 1996; Thompson[1]). By the spring, loggerhead sea turtles, *Caretta caretta*, were sighted as far north as Delaware Bay and leatherback sea turtles, *Dermochelys coriacea*, were more widely distributed farther north (Shoop and Kenney, 1992). Aerial surveys of the Middle Atlantic States demonstrated densities of loggerheads to be greatest south of Cape Hatteras in April but by May, densities were highest north of the Cape (Musick et al., 1994). During the summer, sightings documented by aerial surveys increased but were more concentrated in certain areas. Sea turtles in the northern part of the United States were mainly distributed between Cape Hatteras, N.C., and Long Island, N.Y., (Shoop and Kenney, 1992) while surveys in the southeastern United States waters revealed sea turtles mainly distributed off Florida (Thompson and Huang, 1993; Thompson[1]). By fall, sightings had decreased with most sea turtles observed in the southern part of the study area, with a more random distribution (Shoop and Kenney, 1992; Thompson and Huang, 1993; Witzell and Azarovitz, 1996).

Likewise, long-distance recapture records of immature loggerheads from the nearshore waters of Cape Canaveral, Fla., indicated a northward movement toward warming waters during the spring and summer (Henwood, 1987; Schmid, 1995). Of 475 recaptured immature loggerheads tagged in the vicinity of Cape Canaveral, Fla., 29 were recaptured more than 100 n.mi. from the study area, mostly to the north in the coastal waters of Georgia, the Carolinas, and Virginia (Henwood, 1987). Most of these long-distance recaptures (22 of 29) were initially tagged in the Cape Canaveral

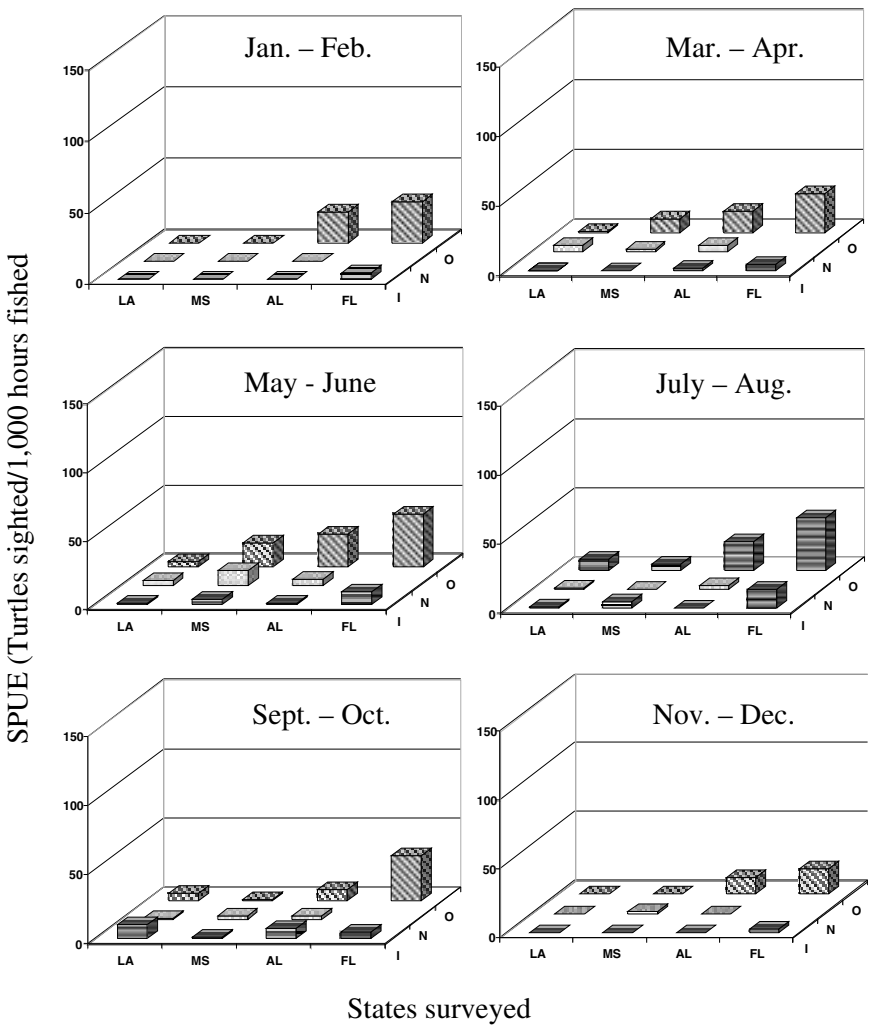

Figure 2.—Frequency distribution of sea turtles sighted by recreational anglers interviewed along the U.S. Gulf of Mexico coast during intercept interviews of the Marine Recreational Fishery Statistics Survey, 1991–92. Total number of sea turtle sightings/1,000 h fished are given bimonthly for each state. Absence of data indicates no anglers were interviewed. Texas is not included in the survey. I=Inshore; N=Nearshore; O=Offshore.

[1]Thompson, N. B. 1984. Progress report on estimating density and abundance of marine turtles: results of first year pelagic surveys in the southeast U.S., 60 p. Unpubl. data on file at NOAA, NMFS Southeast Fisheries Science Center, 75 Virginia Beach Dr., Miami, FL 33149.

area from October to March, while a majority (27 of 29) were recaptured from May to September. In addition, sea turtles initially tagged from Long Island Sound, N.Y., have been recovered as far south as South Carolina and Florida in the same year, suggesting a southward movement (Morreale and Standora, 1995).

The MRFSS documented turtle sightings during late fall and early winter months (November–December) to be mainly from offshore waters. The only inshore sightings during that time were from North Carolina to Florida. Emigration from sounds, bays, and other inshore waters also has been documented through aerial surveys and mark-recapture studies in Delaware (Spotila[2]), Virginia (Keinath et al., 1987), and North Carolina (Epperly et al., 1995a; Epperly et al., 1995b). Sea turtles had emigrated from the inshore waters of Delaware by September, Virginia by November, and North Carolina by December.

MRFSS sighting rates from all Atlantic Coast states peaked from May to August; however, southern states (North Carolina to Florida) demonstrated this peak during May and June while northern state (Virginia to Maine) sightings peaked during July and August. Similarly, aerial surveys of the Atlantic coast noted a peak in turtle densities from Cape Hatteras, N.C., to Cape Cod, Mass., in July and August (Witzell and Azarovitz, 1996), with the majority of sightings from aerial surveys of the northeast United States occurring from Cape Hatteras, N.C., to Long Island, N.Y., during the summer (Shoop and Kenney, 1992). Likewise, during 1991 and 1992, the STSSN reported peaks in strandings for the southeast United States (Atlantic coast of Florida to North Carolina) from April to July and in the northeast United States (Virginia to Maine) from June to August (Teas[3]).

In addition, the MRFSS documented turtle sighting rates from Delaware inshore waters that were comparable to or greater than those for Maryland, Virginia, North Carolina, and South Carolina during the months of May to October (Fig. 1). Similarly, aerial surveys revealed that sea turtles inhabit Delaware Bay from June through September at densities similar to those reported for Virginia, North Carolina, and Georgia (Spotila[2]).

U.S. Gulf of Mexico

In the Gulf of Mexico, MRFSS survey effort was present at all times for all areas except the nearshore waters of Florida and for all of Texas. Similar to the Atlantic coast states, sighting rates increased in the nearshore and inshore waters during the spring and early summer months, peaking during the months of May to August, but the movement of the increase appeared to be in a westward direction. This pattern was reversed during the late summer and fall months with turtle sighting rates greatest from offshore waters on the eastern side of the Gulf of Mexico during late fall and winter months. However, since the MRFSS did not sample Texas, we do not know the sighting rate for the western section of the Gulf of Mexico or if this pattern of movement was evident there as well.

Aerial surveys of the Gulf of Mexico noted similar peaks in density. Lohoefener et al. (1988) estimated greater hard-shelled sea turtle densities from aerial surveys conducted April through July than those conducted September to December. Fritts et al. (1983) sighted the highest number of loggerheads in April and the lowest number in December. Likewise, from 1991 to 1992, strandings in the Gulf of Mexico (Texas to the Florida Gulf coast) peaked in April, July, and August (Teas[3]). In contrast, Thompson et al. (1991) reported more sightings in the fall (September and October) than the summer (June to August).

Aerial surveys of the Gulf of Mexico have revealed lower turtle densities from the western side of the Gulf than the eastern (Fritts et al., 1983; Lohoefener et al., 1988; Thompson et al., 1991). According to Fritts et al. (1983), loggerheads were 50 times more abundant in the waters off of western Florida than off of Louisiana and Texas. Likewise, the MRFSS documented the fewest turtle sightings in Louisiana (Texas was not included in the survey) with the greatest sightings along the gulf coast of Florida. In contrast, the number of strandings from Texas (41%) were comparable to those from the gulf coast of Florida (48%) (Teas[3]). Overall, MRFSS sightings from Louisiana were low compared to the other Gulf of Mexico states, similar to what Lohoefener et al. (1988) reported from aerial surveys. Similar to the eastern coast of Florida, the MRFSS documented the presence of sea turtles off the western coast of Florida at all times of the year.

No methodology of obtaining sea turtle distributional data is without limitations. Glare, lack of water clarity, observer inexperience (Henwood and Epperly, 1999), and the limited (3.8–41%) time turtles spend on the surface (Kemmerer et al., 1983; Keinath et al., 1987; Byles, 1989) can impact an observer's ability to sight a turtle during an aerial survey. Sea surface conditions (Lee and Palmer, 1981) and a more confined area of coverage (due to the observer's close proximity to the water's surface) also can restrict the distributional data shipboard surveys can collect. The possibility that a dead sea turtle might drift some distance before washing up on shore and lack of consistent effort along all shorelines are limitations of sea turtle strandings providing distributional data. Finally, it can take years of labor-intensive effort before mark-recapture data depict the spatio-temporal distributions of sea turtles.

Likewise, the MRFSS is not without its limitations. The MRFSS does not provide species or size composition of sea turtles sighted, and effort varies depending upon location of fishing activity and time of year anglers are queried.

Despite these limitations, the information gained from the interviews of anglers can be used to corroborate or supplement distributional data obtained from more systematic (aerial, shipboard, strandings) or other opportunistic (mark-recapture, reports of sea turtle sightings by the general public or commercial fishermen) surveys. In addition, the MRFSS is the only

[2]Spotila, J. R., P. T. Plotkin, and J. A. Keinath. Unpubl. In-water population survey of sea turtles of Delaware Bay. Final report to NMFS Office Prot. Resour., Silver Spring, Md., 21 p. Drexel Univ., 3141 Chestnut St., Philadephia, PA 19104.

[3]Teas, W. Unpubl. data in 1992 annual report of the Sea Turtle Stranding and Salvage Network, Atlantic and Gulf Coasts of the United States, Jan.–Dec. 1992, p. 1–43. NOAA, NMFS Southeast Fisheries Science Center, 75 Virginia Beach Dr., Miami, FL 33149.

methodology that provides a means of ascertaining synoptic distributional data of sea turtles simultaneously along both the Atlantic and Gulf of Mexico coasts (from Maine to Louisiana) for inshore waters as well as offshore waters out to the Exclusive Economic Zone.

The "turtle question" has not been included in the MRFSS since 1992. Because of the valuable sea turtle distributional data that can be obtained from asking anglers this question, we recommend that its inclusion in the MRFSS program be revisited.

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Literature Cited

Byles, R. A. 1989. Satellite telemetry of Kemp's ridley sea turtles, *Lepidochelys kempii*, in the Gulf of Mexico. *In* S. A. Eckert, K. L. Eckert, and T. H. Richardson (Editors), Proceedings of the Ninth Annual Workshop on Sea Turtle Conservation and Biology, p. 25–26. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFC-232.

Carr, A. F., A. Meylan, J. Mortimer, K. A. Bjorndal, and T. Carr. 1982. Surveys of sea turtle populations and habitats in western Atlantic. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFC-91, 91 p.

Epperly, S. P., J. Braun, and A. J. Chester. 1995a. Aerial surveys for sea turtles in North Carolina inshore waters. Fish. Bull. 93:254–261.

_____ , J. Braun, and A. Veishlow. 1995b. Sea turtles in North Carolina waters. Conserv. Biol. 9(2):384–394.

Essig, R. J., and M. C. Holliday. 1991. Population and longitudinal surveys. Development of a recreational fishing survey: the Marine Recreational Fishery Statistics Survey case study. *In* D. Guthrie (Editor), Creel and angler surveys in fisheries management: Proceedings of the International Symposium and Workshop on Creel and Angler Surveys in Fisheries Management, p. 245–254. Am. Fish. Soc., Bethesda, Md.

Fritts, T. H., W. Hoffman, and M. A. McGehee. 1983. The distribution and abundance of marine turtles in the Gulf of Mexico and nearby Atlantic waters. J. Herpetol. 17(4):327–344.

Henwood, T. A. 1987. Movements and seasonal changes in loggerhead turtle *Caretta caretta* aggregations in the vicinity of Cape Canaveral, Florida (1978–84). Biol. Conserv. 40 (1987):191–202.

_____ and S. P. Epperly. 1999. Aerial surveys in foraging habitats. *In* K. L. Eckert, K. A. Bjorndal, F. A. Abreu-Grobois, and M. Donnelly (Editors), Research and management techniques for the conservation of sea turtles, p. 65–66. IUCN/SSC Marine Turtle Specialist Group Publ. 4. Consolidated Graphic Communications, Blanchard, Pa.

_____ and L. H. Ogren. 1987. Distribution and migrations of immature Kemp's ridley turtles (*Lepidochelys kempi*) and green turtles (*Chelonia mydas*) off Florida, Georgia, and South Carolina. Northeast Gulf Sci. 9(2):153–159.

Keinath, J. A., J. A. Musick, and R. A. Byles. 1987. Aspects of the biology of Virginia's sea turtles: 1979–1986. Va. J. Sci. 38(4):329–336.

Kemmerer, A. J., R. E. Timko, and S. B. Burkett. 1983. Movement and surfacing behavior patterns of loggerhead sea turtles in and near Canaveral Channel, Florida (September and October 1981). U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFC-112, 43 p.

Lee, D. S., and W. M. Palmer. 1981. Records of leatherback turtles and other marine turtles. Brimleyana 5:95–106.

Lohoefener, R. R., W. Hoggard, C. L. Roden, K. D. Mullin, and C. M. Rogers. 1988. Distribution and relative abundance of surfaced sea turtles in the north-central Gulf of Mexico: spring and fall 1987. *In* B. A. Schroeder (Editor), Proceedings of the Eighth Annual Workshop on Sea Turtle Conservation and Biology, p. 47–50. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFC-202.

Morreale, S. J., and E. A. Standora. 1995. Cumulative evidence of southward migration of juvenile sea turtles from temperate northeastern waters. *In* J. E. Richardson and T. H. Richardson (Editors), Proceedings of the Twelfth Annual Workshop on Sea Turtle Biology and Conservation, p. 85–86. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFSC-361.

Musick, J. A., D. E. Barnard, and J. A. Keinath. 1994. Aerial estimates of seasonal distribution and abundance of sea turtles near the Cape Hatteras faunal barrier. *In* B. A. Schroeder and B. E. Witherington (Editors), Proceedings of the Thirteenth Annual Symposium on Sea Turtle Biology and Conservation, p. 121–123. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFSC-341.

National Research Council. 1990. Decline of the sea turtles. Natl. Acad. Press, Wash., D.C., 259 p.

Schmid, J. R. 1995. Marine turtle populations on the east-central coast of Florida: results of tagging studies at Cape Canaveral, Florida, 1986–1991. Fish. Bull. 93:139–151.

Schroeder, B. A. 1989. Marine turtle data base management: National Marine Fisheries Service-Miami Laboratory. *In* C. W. Caillouet, Jr., and A. M. Landry, Jr. (Editors), Proceedings of the First International Symposium on Kemp's Ridley Sea Turtle Biology, Conservation and Management, p. 153–15. Tex. A&M Univ. Sea Grant Coll. Prog. Rep. TAMU-SG-89-105.

Shoop, C. R., and R. D. Kenney. 1992. Seasonal distributions and abundances of loggerhead and leatherback sea turtles in waters of the northeastern United States. Herpetolog. Monogr. 6:43–67.

Thompson, N. B., E. S. Denton, D. B. Koi, A. Martinez, and K. D. Mullin. 1991. Turtles in the Gulf of Mexico: pelagic distributions and commercial shrimp trawling. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFSC-286, 24 p.

_____ and H. Huang. 1993. Leatherback turtles in southeast U.S. waters. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFSC-318, 11 p.

Witzell, W. N., and T. Azarovitz. 1996. Relative abundance and thermal and geographic distribution of sea turtles off the U.S. Atlantic Coast based on aerial surveys (1963–1969). U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFSC-381, 10 p.