Turtle excluder devices—Are the escape openings large enough?*

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Abstract—All five species of sea turtles in continental U.S. waters are protected under the Endangered Species Act of 1973 and the population sizes of all species remain well below historic levels. Shrimp trawling was determined to be the largest source of anthropogenic mortality of many of the species. As a mechanism to reduce the incidental catch of turtles in trawl nets, turtle excluder devices have been required intermittently in the shrimp fishery since 1987, and at all times since 1994. The expanded turtle excluder device (TED) regulations, implemented in 1994, were expected to reduce shrimp trawl capture of sea turtles by 97%. Recent evidence has indicated that the sizes of turtles stranding were not representative of the animals subjected to being captured by the shrimp trawlers. The purpose of our study was to compare the sizes of stranded sea turtles with the size of the TED openings. We compared the sizes of stranded loggerhead (*Caretta caretta*), green (*Chelonia mydas*), and Kemp's ridley (*Lepidochelys kempii*) sea turtles, the three species most commonly found stranded, to the minimum widths and heights of TED openings. We found that annually a large proportion of stranded loggerhead turtles (33–47%) and a small proportion of stranded green turtles (1–7%) are too large to fit through the required minimum-size TED openings. The continued high mortality of sea turtles caused by bottom trawling is reason for concern, especially for the northern subpopulation of loggerhead turtles, which currently is not projected to achieve the federal recovery goal of reaching and maintaining prelisting levels of nesting.

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All five species of sea turtles in continental U.S. waters are protected under the Endangered Species Act of 1973 (ESA, PL93-205). Elasticity models of turtle populations have indicated that the life stages with the highest elasticity are juveniles (i.e. a reduction in mortality in these stages would result in the greatest annual population multiplication rate) (Crouse et al., 1987; Crowder et al., 1994; Heppell, 1998a, 1998b; Epperly et al., 2001; Heppell et al., in press). Size data indicate that the sea turtles most often found dead on ocean beaches are immature (Crouse et al., 1987; STSSN[1]) and shrimp trawling is thought to account for the majority of these deaths (Magnuson et al., 1990; Caillouet et al., 1991, 1996; Crowder et al., 1995). Strandings, however, likely represent only a small proportion of the animals that die offshore (TEWG, 1998).

Beginning in the fall of 1987, the National Marine Fisheries Service (NMFS) seasonally required turtle excluder devices (TEDs) in shrimp trawl nets on most vessels operating in ocean waters off the southeastern U.S. as a mechanism to reduce the incidental catch of turtles in general and the catch of the large immature turtles in particular (Federal Register, 1987); vessels operating off Cape Canaveral and off southwest Florida were required to use TEDs all year. Boats working in inshore waters were allowed to use tow time limits in lieu of TEDs. The difference between offshore and inshore regulations was due, in part, to the lack of information on the distribution and abundance of sea turtles in inshore waters and to the lack of documentation of incidental captures by shrimp trawlers working in these inshore waters (Federal Register 1992a). For the first few years implementation of the regulations was delayed by challenges in the courts and in Congress. The regulations were implemented fully in Spring 1990.

Evidence of the importance of inshore areas to sea turtles, along with evidence that shrimp trawlers catch sea turtles in inshore waters (Epperly et al., 1995; NMFS[2]) provided sufficient justification for NMFS to expand requirements for turtle excluder devices in the shrimp fishery to all areas at all times, including inshore waters; full implementation of these requirements was achieved by December 1994 (Federal Register, 1992a, 1992c). The expanded TED regulations were expected to reduce shrimp trawling capture of sea turtles by 97% (Henwood et al., 1992). Since 1992, TEDs also have been required in the winter trawl fishery for summer flounder operating as far north as Cape Charles, Virginia (Federal Register, 1992b).

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[1] STSSN (Sea Turtle Stranding and Salvage Network). 1998. Unpubl. data. The Sea Turtle Stranding and Salvage Network is a cooperative endeavor between NMFS, other federal agencies, the states, many academic and private entities, and innumerable volunteers. Data are archived at the National Marine Fisheries Service Southeast Fisheries Science Center, 75 Virginia Beach Dr., Miami, FL 33149.

[2] NMFS (National Marine Fisheries Service). 1990. Unpubl. data. NMFS Galveston Laboratory, 4700 Avenue U, Galveston, TX 77551.

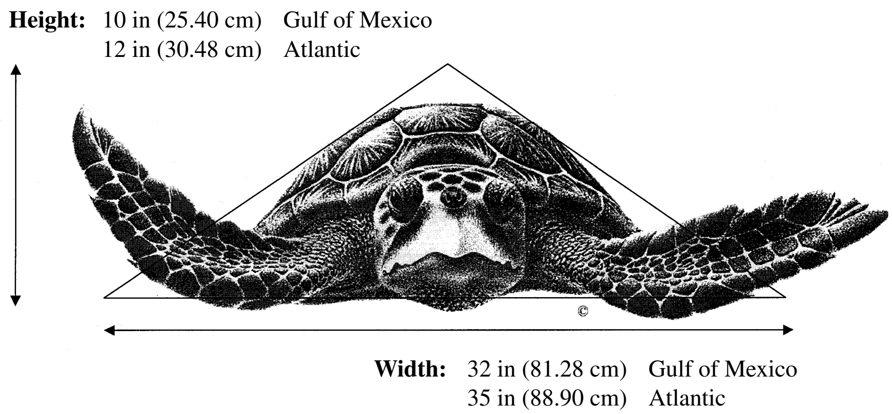

Figure 1

Minimum dimensions (height and width) specified in current U.S. federal regulations (Federal Register, 1992c) for escape openings in single-grid hard turtle excluder devices. The copyrighted figure of the turtle was kindly provided by Jamie Serino of Flying Turtle Productions.

TEDs are equipped with a trap door that allows sea turtles to escape from trawl nets (Seidel and McVea, 1982) and may be either rigid or soft in design (Federal Register, 1992c). To be certified by NMFS, a TED design must be 97% effective, in comparison with a control net, in excluding sea turtles (Federal Register 1987, 1992c). Since 1990, turtles used for TED trials have been small loggerhead turtles, mostly 2-yr-olds that have averaged 34.4 cm SCL (SD=4.1, n=1730, NMFS[3]). Regardless of design, certain parameters of the TED architecture are regulated. Most important to this discussion are the requirements of the height and width dimensions of the opening in the net through which turtles escape. Along the Atlantic Coast these requirements are width ≥35 in (88.90 cm) and height ≥12 in (30.48 cm) (Federal Register,1992c). In the Gulf of Mexico these measurements are ≥32 inch (81.28 cm) and ≥10 inch (25.40 cm), respectively. Height is measured simultaneously with width and is measured at the midpoint of the straight-line distance of width (i.e. the width and height of a taut triangle is measured, Fig. 1).

The purpose of our study was to compare the sizes of stranded sea turtles with the size of the TED openings. This evaluation was prompted by the need, identified by the NMFS Turtle Expert Working Group (TEWG), to reduce the strandings of mature loggerhead sea turtles (*Caretta caretta*) from the northern subpopulation (TEWG, 1998). We compared the sizes of stranded loggerhead, green (*Chelonia mydas*), and Kemp's ridley (*Lepidochelys kempii*) sea turtles, the three species most commonly found stranded, to the minimum widths and heights of TED openings.

[3] NMFS (National Marine Fisheries Service). 2001. Unpubl. data. Galveston Laboratory, National Marine Fisheries Service, 4700 Ave. U, Galveston, TX 77551.

Materials and methods

To compare the sizes of stranded turtles with the minimum size of TED openings we first constructed a predictor of carapace width and body depth. Thus, a morphometric analysis for each species was conducted, generally with data from reared, live captured, or nesting turtles and not with data from strandings. The predictive regression for carapace width was then applied to the strandings data when this measurement was not recorded for a given turtle; the predictive regression for body depth was applied to all turtles in the database because body depth was rarely measured at stranding sites. We then analyzed the entire strandings database to compare turtle sizes with the minimum size of TED openings.

Morphometric analyses

The species-specific relationship between both body depth and carapace width with carapace length was explored through regression analysis and predictive regression equations were developed. Regressions of untransformed data were compared with regressions of $\log_e$-transformed data by comparing goodness-of-fit values.

Morphometric data (straight line carapace length, notch-to-tip [SCL], straight line carapace width [SCW], and body depth [BD]) were recorded by a number of researchers throughout the southeast United States and at the Cayman Turtle Farm, Cayman Islands. Data for loggerhead turtles were concentrated in the 20–30 cm and 30–40 cm SCL size classes and were censored (randomized selection of n=37 in each of the two size classes) to create a more uniform distribution for the analysis (Table 1). Green turtle data were more uniformly distributed across size classes and were not censored (Table 1). Data for Kemp's ridley turtles were concentrated in the 1–10 cm and 10–20 cm

Table 1
Distribution of sizes of sea turtles used in the morphometric analysis.

Straight carapace length (cm)	Loggerhead		Green	Kemp's ridley	
	Frequency	Censored frequency	Frequency	Frequency	Censored frequency
1.01–10	1	1	17	3032	105
10.01–20	1	1	5	3778	105
20.01–30	123	37	37	155	155
30.01–40	629	37	49	58	58
40.01–50	24	24	22	137	137
50.01–60	48	48	21	71	71
60.01–70	26	26	16		
70.01–80	10	10	1		
80.01–90	32	32	3		
90.01–100	27	27	2		
100.01–120	7	7	3		

SCL size classes and were censored (randomized selection of n=105) in each of the two size classes (Table 1).

Strandings analyses

The Sea Turtle Stranding and Salvage Network (STSSN) documents dead or injured sea turtles along the coasts of the eastern United States and the U.S. Caribbean (Schroeder, 1989). The STSSN relies on a trained group of volunteers, including state and federal employees and private individuals, to collect basic biological data on each stranded turtle. Each animal is identified to species, the condition or state of decomposition is determined, standard carapace measurements are taken, and any obvious wounds, injuries, or abnormalities are noted and described. Volunteers who have received additional training may also perform necropsies, or internal exams, on a carcass to determine the general state of health of the animal prior to death, to determine sex, and to locate any obvious internal abnormalities. Data are recorded on standardized report forms that are submitted first to a state coordinator and then to the national STSSN coordinator at the National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, Florida.

The species-specific predictive regression equations from the morphometric analyses were used to estimate the carapace width for each turtle in the STSSN database for which this measurement had not been taken and to estimate the body depth for each turtle. For turtles with curved measurements only, straight line carapace lengths were estimated from curved carapace lengths (CCL) before estimating body depth and carapace width by applying equations reported by Teas (1993).

Within each region (Fig. 2) carapace widths were compared with the currently required minimum widths of TED openings and body depths were compared with the currently required minimum heights of TED openings. Stranded turtles that were reared in captivity, cold-stunned, or known to have been captured incidentally were censored.

Results

Morphometric analyses

Loggerhead sea turtles The relationships between carapace width and carapace length and between body depth and carapace length were linear. Coefficient of determination (r^2) values of regressions with $\log_e$-transformed data were slightly (<0.002) higher than values based on untransformed data. Regression of each of the morphometric values on carapace length was highly significant (P<0.0001) and resulted in the following predictive equations:

$$\ln SCW = -0.0225 + (0.9507 \times \ln SCL) \quad [n=250, r^2=0.989],$$

$$\ln BD = -0.5682 + (0.9100 \times \ln SCL) \quad [n=250, r^2=0.966].$$

Straight line carapace lengths corresponding to turtles with carapace widths of 81.28 cm (32 inch; the minimum width of TED openings in the Gulf of Mexico) and 88.90 cm (35 inch; the minimum width of TED openings in the Atlantic) were 104.5 cm and 114.9 cm, respectively. Straight line carapace lengths corresponding to turtles with body depths of 25.40 cm (10 inch is the minimum height of TED openings in the Gulf of Mexico) and 30.48 cm (12 inch is the minimum height of TED openings in the Atlantic) were 65.3 cm and 79.8 cm, respectively.

Green sea turtles The relationships between carapace width and carapace length and between body depth and

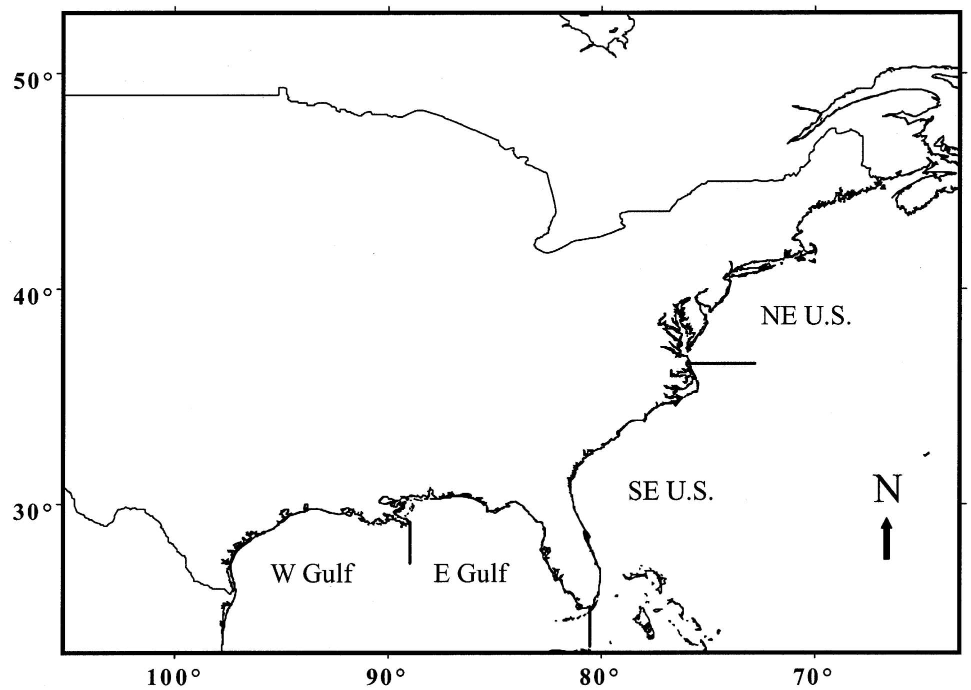

Figure 2

Regions of reported sea turtle strandings along the coasts of the eastern United States and the Gulf of Mexico.

carapace length were linear. Coefficient of determination (r^2) values of regressions with $\log_e$-transformed data were slightly (<0.015) higher than values based on untransformed data. Regression of each of the morphometrics on carapace length was highly significant (P<0.0001) and resulted in the following predictive equations:

$\ln SCW = -0.1608 + (0.9812 \times \ln SCL)$, [$n$=176, r^2=0.995],

$\ln BD = -1.0115 + (1.0023 \times \ln SCL)$, [$n$=176, r^2=0.977].

Straight line carapace lengths corresponding to turtles with carapace widths of 81.28 cm (32 inch) and 88.90 cm (35 inch) were 104.2 cm and 114.1 cm, respectively. Straight line carapace lengths corresponding to turtles with body depths of 25.40 cm (10 inch) and 30.48 cm (12 inch) were 69.2 cm and 83.0 cm, respectively.

Kemp's ridley sea turtles The relationships between carapace width and carapace length and between body depth and carapace length were linear. Coefficient of determination (r^2) values of regressions with $\log_e$-transformed data were slightly (<0.006) higher than values based on untransformed data. Regression of each of the morphometrics on carapace length was highly significant (P<0.0001) and resulted in the following predictive equations:

$\ln SCW = -0.2039 + (1.0437 \times \ln SCL)$ [n=631, r^2=0.998],

$\ln BD = -0.6283 + (0.9075 \times \ln SCL)$, [$n$=631, r^2=0.989].

Straight line carapace lengths corresponding to turtles with carapace widths of 81.28 cm (32 inch) and 88.90 cm (35 inch) were 82.2 cm and 89.6 cm, respectively. Straight line carapace lengths corresponding to turtles with body depths of 25.40 cm (10 inch) and 30.48 cm (12 inch) were 70.6 cm and 86.3 cm, respectively.

Strandings analyses

Straight carapace length and width were not measured for a number of stranded sea turtles; body depth almost never was recorded. The total number of records, by species, for which the predictive regressions were applied to estimate straight carapace length or straight carapace width are given in Table 2. Note that the length of a turtle, straight line or curved, must have been measured for the turtle to be included in the analyses because the predictive measures were based on length. It should also be noted that the conclusions from the strandings analyses were not altered by the choice of linear or log-transformed data in the morphometric analyses above.

Loggerhead sea turtles

Carapace width Strandings of loggerhead turtles with carapace widths greater than the currently required minimum widths of TED openings have not exceeded 1%

of the total measured strandings in any year since 1986 (Table 3). The majority of the stranded large (wide) turtles occur in the eastern Gulf of Mexico and the southeast U.S. Atlantic regions, areas where significant nesting occurs.

Body depth Strandings of loggerhead turtles with body depths greater than the currently required minimum heights of TED openings have ranged between 33% and 47% of the total stranded turtles measured every year since 1986 [Table 4]). From 1995 to 1997 nearly 1300 stranded loggerhead turtles were deeper bodied that the currently required minimum TED height opening. The highest proportion of turtles that were too deep bodied to pass through TEDs was found to be in the Gulf of Mexico where TED openings are smaller. The greatest numbers of large turtle strandings occurred on nesting beaches of the eastern Gulf of Mexico and the southeast U.S. Atlantic.

Table 2

The total number of records, by species, for which the predictive regressions were applied to estimate straight line carapace length or straight line carapace width for loggerhead, green, and Kemp's ridley sea turtles.

Missing measurement	Loggerhead	Green	Kemp's ridley
Straight line carapace length	8340	1034	1209
Straight line carapace width	8555	1089	1261

Green sea turtles

Carapace width Strandings of green turtles with carapace widths greater than the currently required minimum width of TED openings have not exceeded two turtles or 2% of the total stranded turtles measured in any year since 1986 (Table 5).

Body depth Strandings of green turtles with body depths greater than the currently required minimum height of TED openings have ranged between 1% and 7% of the total stranded turtles measured since 1986 (Table 6). The large turtles were found sranded in the eastern Gulf of Mexico and the southeast U.S. Atlantic regions, the latter an area of nesting activity.

Kemp's ridley sea turtles

None of the nearly 3000 measured Kemp's ridley turtles that stranded during 1986–97 (total stranded=3476) had carapace widths or body depths greater than the currently required minimum widths and heights of TED openings.

Discussion

All ESA-listed species of sea turtles remain below their historic levels of abundance. The status of Kemp's ridley and loggerhead sea turtles was recently evaluated by the NMFS Turtle Expert Working Group (1998; 2000). Kemp's ridley turtles constitute a single management unit and the nesting population is increasing. If the population continues to grow exponentially, the recovery goal of downlisting

Table 3

Number of stranded loggerhead sea turtles and percentage of those measured with (predicted) carapace widths greater than the minimum width of openings currently required in turtle excluder devices.

	Region of stranding											
	Western Gulf		Eastern Gulf		SE U.S. Atlantic		NE U.S. Atlantic		All regions			
Year	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	Total number measured	Total number stranded
1986	0	0	2	2	5	1	1	5	8	1	959	1209
1987	1	1	3	2	5	1	0	0	9	1	1318	1728
1988	0	0	5	3	1	0	1	1	8	1	1105	1373
1989	0	0	3	1	1	4	0	0	7	1	1088	1425
1990	0	0	3	3	4	0	0	0	7	1	1258	1592
1991	0	0	2	2	1	0	0	0	3	0	777	975
1992	1	2	0	0	1	0	0	0	2	0	798	1101
1993	0	0	1	1	0	0	1	1	2	0	693	972
1994	0	0	5	7	2	0	0	0	7	1	1044	1342
1995	0	0	1	1	0	0	1	1	4	0	973	1424
1996	0	0	1	1	1	0	2	1	4	0	1461	1883
1997	0	0	6	4	0	0	2	1	8	1	1289	1643

the species from endangered to threatened status (10,000 females nesting in a season) will be met early in this century (TEWG, 2000). There are five known subpopulations of loggerhead turtles in the Western North Atlantic (Encalada et al., 1998; Francisco Pearce, 2001; Francisco et al., in press) but the status of only two could be addressed by the TEWG. Nesting levels of the South Florida subpopulation appear to be increasing, meeting one of the recovery goals set for Florida loggerhead sea turtles. The northern subpopulation, which nests from northern

Table 4

Number of stranded loggerhead sea turtles and percentage of those measured with predicted body depths greater than the minimum height of openings currently required in turtle excluder devices.

	Region of stranding										
	Western Gulf		Eastern Gulf		SE U.S. Atlantic		NE U.S. Atlantic		All regions		
Year	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	Total number measured
1986	68	44	72	89	188	27	4	24	332	35	954
1987	75	54	123	96	225	23	11	25	434	33	1309
1988	62	56	134	96	187	25	6	17	389	38	1027
1989	41	44	209	92	179	26	4	19	433	42	1042
1990	48	36	91	88	250	27	6	22	395	33	1188
1991	37	54	73	83	162	31	18	30	290	40	734
1992	35	58	66	85	198	34	13	28	312	41	763
1993	26	47	76	89	182	40	12	28	296	47	636
1994	97	57	64	88	237	35	15	15	413	41	1010
1995	56	52	66	90	207	30	18	19	347	36	956
1996	99	52	127	88	253	27	33	20	512	36	1436
1997	97	66	131	87	171	23	29	14	428	34	1266

Table 5

Number of stranded green sea turtles and percentage of those measured with (predicted) carapace widths greater than the minimum width of openings currently required in turtle excluder devices.

	Region of stranding											
	Western Gulf		Eastern Gulf		SE U.S. Atlantic		NE U.S. Atlantic		All regions			
Year	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	Total number measured	Total number stranded
1986	0	0	2	22	0	0	0	0	2	2	101	125
1987	0	0	0	0	0	0	0	0	0	0	122	142
1988	0	0	0	0	0	0	0	0	0	0	178	193
1989	0	0	0	0	0	0	0	0	0	0	223	255
1990	0	0	0	0	0	0	0	0	0	0	280	308
1991	0	0	0	0	0	0	0	0	0	0	200	221
1992	0	0	1	4	0	0	0	0	1	1	184	208
1993	0	0	0	0	0	0	0	0	0	0	180	200
1994	0	0	0	0	0	0	0	0	0	0	268	320
1995	0	0	0	0	0	0	0	0	0	0	312	389
1996	0	0	0	0	1	0	0	0	1	0	508	584
1997	0	0	0	0	0	0	0	0	0	0	286	352

Table 6

Number of stranded green turtles and percentage of those measured with predicted body depths greater than the minimum height of openings currently required in turtle excluder devices.

	Region of stranding										
	Western Gulf		Eastern Gulf		SE U.S. Atlantic		NE U.S. Atlantic		All regions		Total number measured
Year	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	
1986	1	17	3	33	3	4	0	0	7	7	100
1987	2	13	3	12	3	4	0	0	8	7	122
1988	1	11	2	8	2	1	0	0	5	3	177
1989	3	21	3	9	6	3	0	0	12	5	219
1990	0	0	1	2	9	4	0	0	10	4	277
1991	0	0	3	8	3	2	0	0	6	3	196
1992	0	0	2	8	8	6	0	0	10	6	180
1993	0	0	4	11	4	3	1	33	9	5	175
1994	1	2	4	12	9	5	0	0	14	5	258
1995	0	0	1	2	3	1	0	0	4	1	301
1996	1	2	10	9	10	3	0	0	21	4	500
1997	1	3	4	10	7	3	0	0	12	4	282

Florida through North Carolina may now be stable but is currently well below goals set for its recovery (return to prelisting nesting levels). Mortality on at least the northern subpopulation of loggerhead sea turtles needs to be reduced throughout its range to ensure recovery.

Although subpopulations of loggerhead turtles can be easily distinguished by the geographic location of their nesting beaches, the subpopulations comingle on the foraging grounds (Sears, 1994; Norrgard, 1995; Sears et al., 1995; Rankin-Baransky et al., 2001; Witzell et al., 2002; Bass et al., in press). Genetic studies of foraging and stranded animals indicate that the immature benthic animals of the northern subpopulation are distributed along the Atlantic seaboard (Sears, 1994; Norrgard, 1995; Sears et al., 1995; Rankin-Baransky et al., 2001; Witzell et al., 2002; Bass et al., in press), in Florida Bay (Bass et al.[4]), and in the Gulf of Mexico (Bass et al.[5]). Non-nesting adult females from the northern subpopulation appear to occur exclusively along the east coast of the United States with rare exception, and none have been reported from international waters (Bell and Richardson, 1978; Williams and Frick, 2001; CMTTP[6]).

Eight nesting subpopulations were identified for green turtles in the Atlantic Ocean (Encalada et al., 1996), but later were reduced to five regional population units (Bass and Witzell, 2000). Like loggerheads, the subpopulations comingle on the foraging grounds (Bass et al., 1998; Lahanas et al., 1998; Bass and Witzell, 2000). The status of all these subpopulations has not been evaluated, but it appears that nesting levels are increasing on the east coast of Florida (Meylan et al., 1995; Florida Fish and Wildlife Conservation Commission[7]) as well as at Tortuguero, Costa Rica, the largest Western Atlantic rookery (Bjorndal et al., 1999).

A large proportion of stranded loggerhead turtles and a small proportion of stranded green turtles are too large to pass through the required minimum-sizes for TED openings. This finding is corroborated by analyses that suggest that the size distribution of stranded loggerheads is different (larger) than the size distribution of turtles in the nearshore waters (TEWG, 2000). The relatively large proportion of stranded loggerhead turtles with dimensions greater than the minimum height required for TED openings is cause for concern in light of the need to reduce mortality on the northern subpopulation of loggerhead sea

[4] Bass, A. L., M. Clinton, and B. W. Bowen. 1998. Loggerhead turtles (*Caretta caretta*) in Florida Bay: an assessment of origin based on genetic markers. Unpubl. report to Florida Department of Environmental Protection, 5 p. Department of Fisheries and Aquatic Sciences, University of Florida, Gainesville, 7922 NW 71st St., Gainesville, FL 32653.

[5] Bass, A. L., S.-M. Chow, and B. W. Bowen. 1999. Final report for project titled: genetic identities of loggerhead turtles stranded in the Southeast United States. Unpubl. report to National Marine Fisheries Service, order number 40AANF 809090, 11 p. Department of Fisheries and Aquatic Sciences, University of Florida, 7922 NW 71st St., Gainesville, FL 32653.

[6] CMTTP (Cooperative Marine Turtle Tagging Program). 2001. Unpubl. data. The Cooperative Marine Turtle Tagging Program was established by NMFS in 1980 to centralize the tagging programs among sea turtle researchers, distribute tags, manage tagging data, and facilitate exchange of tag information. Since 1999 the CMTTP has been managed by the Archie Carr Center for Sea Turtle Research at the University of Florida, PO Box 118525, Gainesville, FL 32511.

[7] Florida Fish and Wildlife Conservation Commission. 2001. Unpubl. data. 100 Eighth Avenue S.E., St. Petersburg, FL 33701

turtles (TEWG, 1998; 2000) and indicates that, for loggerhead sea turtles, TEDs have not achieved a 97% reduction in captures by shrimp trawlers. Loggerhead turtles are exceeding in size the required minimum height of openings in TED before reaching maturity, especially in the Gulf of Mexico where the allowed opening is smaller than that in the Atlantic. This anomaly had not been noted previously because, since 1990, turtles used for TED trials have been small (<21 cm in body depth, n=1415; NMFS[3]). Based on stage elasticities, a proportional reduction in mortality in the smallest size classes not fitting through the TED openings (large immature turtles) would result in the greatest increased annual population multiplication rate (Crouse et al., 1987; Heppell, 1998a; Epperly et al., 2001). A reduction in subadult and adult mortality from drowning in trawls would benefit all species and subpopulations of sea turtles (Heppell, 1998b).

To decrease the mortality on large turtles caused by trawling, the opening dimensions of TEDs need to be larger than the current minimum requirements and need to be the same in the Gulf of Mexico and the Atlantic. Possible management options include the following: 1) increase the dimensions to accommodate some desired proportion of adults or the total population and 2) adopt the "leatherback" modification (Federal Register, 1993, 1994, 1995) for all areas and all times, which would allow the exclusion of turtles of all sizes, including leatherbacks which are the largest of the sea turtles. In response to our findings, an advance notice of a proposed rulemaking, to effect a change in TED requirements, was issued by NMFS (Federal Register, 2000). After consideration of public comments, NMFS advertised a proposed rule to change the TED requirements (Federal Register, 2001). NMFS should also consider extending the TED regulations to other bottom trawl fisheries of the Gulf of Mexico and along the Atlantic seaboard, including in the Northeast United States, whenever turtles and bottom trawling activity may co-occur.

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