NMFS SEFSC Contribution PRD-98/99-08

EVALUATION OF TED OPENING DIMENSIONS RELATIVE TO SIZE OF TURTLES STRANDING IN THE WESTERN NORTH ATLANTIC

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U. S. Department of Commerce
National Oceanic and Atmospheric Administration
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Southeast Fisheries Science Center
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INTRODUCTION

All five species of sea turtles in continental U.S. waters are protected under the Endangered Species Act of 1973 (PL93-205). Elasticity models of turtle populations have identified the large juveniles and adults as life stages with the highest elasticities (*i.e.*, a reduction in mortality in these stages would result in the greatest annual population multiplication rate) (Crouse *et al.*, 1987; Heppell, 1998*a*, *b*). The stage most frequently found dead on ocean beaches is large immature sea turtles (Crouse *et al.*, 1987; NMFS unpubl. data) 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).

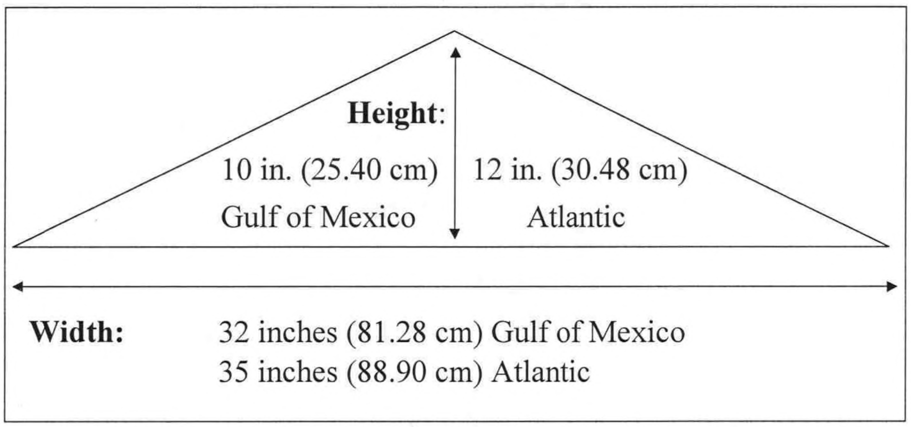
Beginning in the fall of 1987, the National Marine Fisheries Service (NMFS) seasonally required Turtle Excluder Devices (TEDs) in shrimp trawl nets on most boats operating in ocean waters off the southeastern U.S. as a mechanism to reduce the incidental catch of turtles in general and the catch of the large immature stage in particular (Federal Register, 1987). 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 1992*a*). Full implementation of the regulations was delayed until 1989 in offshore waters and until 1990 in inshore waters.

Evidence of the importance of inshore areas to sea turtles, along with evidence that shrimp trawlers catch sea turtles in inshore waters (Renaud *et al.*, 1991; Edward F. Klima, unpubl. data; Epperly *et al.*, 1995) 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, 1992*a*, 1992*b*). The expanded TED regulations were expected to reduce shrimp trawling capture of sea turtles by 97% (Henwood *et al.*, 1992).

TEDs incorporate a trap door to allow sea turtles to escape from trawl nets (Seidel and McVea, 1982) and may be either rigid or soft in design (Federal Register, 1992*b*). To be certified by NMFS, a TED design must be 97% effective in excluding sea turtles (Federal Register 1987, 1992*b*). 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 ≥35 in (88.90 cm) for width and ≥12 in (30.48 cm) for height (Federal Register, 1992*b*). In the Gulf of Mexico these measurements are ≥32 in (81.28 cm) and ≥10 in (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 this 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 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 in the strandings, to the minimum opening sizes of TEDs.

Figure 1. Mimimum TED Opening Dimensions.



METHODS

In order to compare the sizes of stranded turtles to the minimum opening sizes of TEDs we first constructed a predictor of body depth and carapace width. Thus, a morphometric analysis for each species was conducted first and generally utilized data from captive reared, live captured, or nesting turtles and not strandings data. 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. A strandings analysis of the entire strandings database, wherein the turtle sizes were compared to minimum openings sizes of TEDs, ensued.

MORPHOMETRIC ANALYSES

The 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 to regressions of log 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 measured by a number of researchers throughout the southeast U.S. and at the Cayman Turtle Farm (see Table 1 in each Appendix 1, 2, and 3). 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 SCL size classes and were censored (randomized selection of n=105) in each of the two size classes (Table 1).

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

Straight Carapace Length (cm)	Loggerhead Frequency	Loggerhead Censored Frequency	Green Frequency	Kemp's Ridley Frequency	Kemp's Ridley 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		

STRANDINGS ANALYSES

The Sea Turtle Stranding and Salvage Network (STSSN) documents dead or injured sea turtles along the coasts of the eastern United States (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 turtle located. 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, determine sex, and locate any obvious internal abnormalities. Data are recorded on standardized report forms which 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 predictive regression equations from the morphometric analyses were used to estimate carapace widths for each turtle in the STSSN database for which these measurements were not taken and to estimate body depths 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. The following equations of Teas (1993) were used :

Loggerhead: $SCL = -1.442 + (0.948 * CCL)$

Green: $SCL = 0.294 + (0.937 * CCL)$

Kemp's ridley: $SCL = 0.013 + (0.945 * CCL)$

Within each region (Fig. 2) carapace widths were compared with the currently required minimum TED width openings and body depths were compared with the currently required minimum TED height openings. Only true strandings were used in the analysis (*e.g.*, captive-reared turtles, cold-stunned turtles, and incidental captures 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. R-square values of regressions using log-transformed data were slightly (<0.002) higher than values based on untransformed data. Regression of each of the morphometrics on carapace length was highly significant (P<0.0001) (Appendix 1: Tables 2, 3, Figs. 1, 2) and resulted in the following predictive equations:

$$\ln SCW = -0.0225 + (0.9507 * \ln SCL),\ r^2 = 0.989$$

$$\ln BD = -0.5682 + (0.9100 * \ln SCL),\ r^2 = 0.966$$

Straight line carapace lengths corresponding to turtles with carapace widths of 81.28 cm (32 in) and 88.90 cm (35 in) are 104.5 cm and 114.9 cm, respectively (Appendix 4). Straight line carapace lengths corresponding to turtles with body depths of 25.40 cm (10 in) and 30.48 cm (12 in) are 65.3 cm and 79.8 cm, respectively.

Green Sea Turtles

The relationships between carapace width and carapace length and between body depth and carapace length were linear. R-square values of regressions using log-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) (Appendix 2, Tables 2, 3, Figs. 1, 2) and resulted in the following predictive equations:

$$\ln SCW = -0.1608 + (0.9812 * \ln SCL),\ r^2 = 0.995$$

$$\ln BD = -1.0115 + (1.0023 * \ln SCL),\ r^2 = 0.977$$

Straight line carapace lengths corresponding to turtles with carapace widths of 81.28 cm (32 in) and 88.90 cm (35 in) are 104.2 cm and 114.1 cm, respectively (Appendix 4). Straight line carapace lengths corresponding to turtles with body depths of 25.40 cm (10 in) and 30.48 cm (12 in) are 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. R-square values of regressions using log-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) (Appendix 3, Tables 2, 3, Figs. 1, 2) and resulted in the following predictive equations:

$$\ln SCW = -0.2039 + (1.0437 * \ln SCL),\ r^2 = 0.998$$

$$\ln BD = -0.6283 + (0.9075 * \ln SCL),\ r^2 = 0.989$$

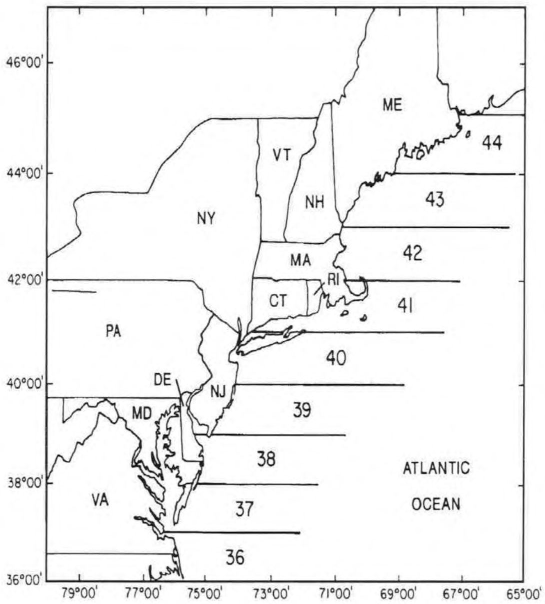
Straight line carapace lengths corresponding to turtles with carapace widths of 81.28 cm (32 in) and 88.90 cm (35 in) are 82.2 cm and 89.6 cm, respectively (Appendix 4). Straight line carapace lengths corresponding to turtles with body depths of 25.40 cm (10 in) and 30.48 cm (12 in) are 70.6 cm and 86.3 cm, respectively.

STRANDINGS ANALYSES

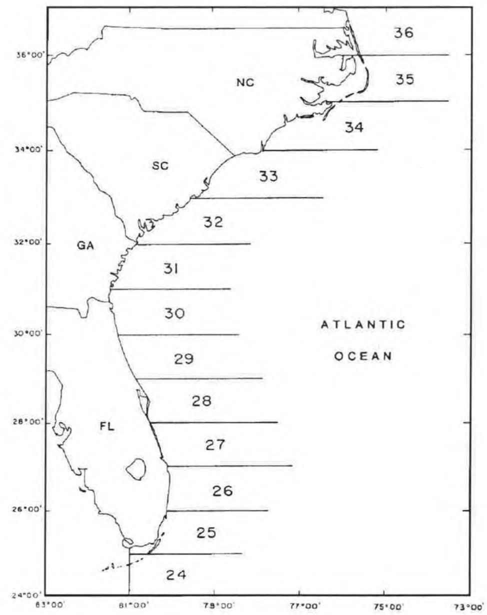
Straight carapace length and width were not measured for a number of stranded sea turtles; body depth almost never was recorded. The total number of records, by species, for which the predictive regressions were applied to estimate straight carapace length or straight carapace width are given in Table 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, since the predictive measures

Figure 2. Regions and strandings zones. A. Northeast U.S. Atlantic, B. Southeast U.S. Atlantic, and C. Gulf of Mexico. Note that the Gulf of Mexico is further divided into two area: Eastern Gulf of Mexico (zones 1-12) and Western Gulf of Mexico (zones 13-21).

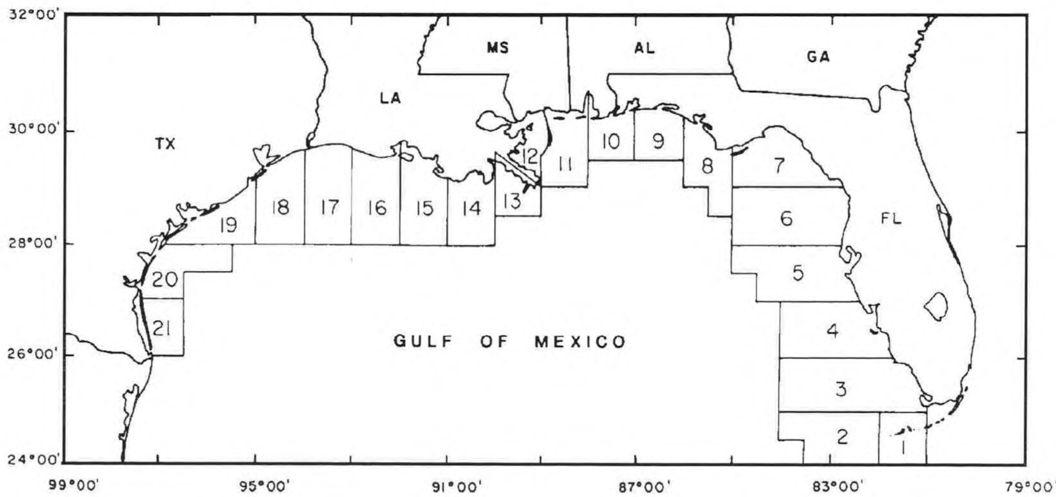
A. Northeast U.S. Atlantic



B. Southeast U.S. Atlantic



C. Gulf of Mexico



are based on length. It should 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.

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.

Missing Measurement	Loggerhead	Green	Kemp's Ridley
Straight Line Carapace Length (but Curved Length was Measured)	8340	1034	1209
Straight Line Carapace Width	8555	1089	1261

Loggerhead Sea Turtles

Carapace Width

Strandings of loggerhead turtles with carapace widths greater than the currently required minimum TED width 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 TED height openings has ranged between 33% and 47% of the total measured strandings since 1986 (Table 4). In the last 3 years nearly 1300 stranded loggerhead turtles were deeper bodied that the currently required minimum TED height opening. The problem is acute in the eastern Gulf of Mexico (Table 4) off the nesting beaches and off the nesting beaches of the Atlantic seaboard (Appendix 1).

Examination of the distribution of body depths of the stranded animals indicates that on average 37.5 cm (14.8 in) represents the 97^{th} percentile (TEDs must be 97% effective in excluding turtles) of the distribution (Table 5). This varies by region, ranging from 34.7 cm (13.7 in) in the Western Gulf of Mexico to 38.5 cm (15.2 in) in both the Eastern Gulf of Mexico and North Atlantic regions.

Table 3. Number of Stranded Loggerhead Turtles and Percentage of Those Measured with [predicted] Carapace Widths Greater than Currently Required TED Width Openings.

	Region of Stranding										Total	Total
	Western Gulf		Eastern Gulf		SEUS Atlantic		North Atlantic		All Regions		Number	Number
Year	N	%	N	%	N	%	N	%	N	%	Measured	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	4	1	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

Table 4. Number of Stranded Loggerhead Turtles and Percentage of Those Measured with Predicted Body Depths Greater than Currently Required TED Height Openings.

	Region of Stranding										Total
	Western Gulf		Eastern Gulf		SEUS Atlantic		North Atlantic		All Regions		Number
Year	N	%	N	%	N	%	N	%	N	%	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. Distribution of Predicted Body Depths (cm) of Stranded Loggerhead Turtles from the U.S. Atlantic Seaboard and the Gulf of Mexico.

	PERCENTILE									
YEAR	90	91	92	93	94	95	96	97	98	99
1986	34.9	35.3	35.6	35.7	36.5	36.8	37.3	38.1	38.8	39.7
1987	34.9	34.9	35.3	35.7	35.9	36.5	37.1	37.3	38.1	39.7
1988	35.3	35.4	35.7	36.1	36.5	36.7	37.3	37.8	38.1	39.0
1989	35.0	35.3	35.7	35.7	35.9	36.1	36.5	36.8	37.3	38.5
1990	35.1	35.4	35.6	35.7	36.1	36.4	36.5	37.1	37.8	39.0
1991	36.1	36.1	36.5	36.5	37.0	37.3	37.6	37.8	38.1	39.0
1992	35.7	35.8	36.1	36.4	36.7	36.9	37.3	37.4	38.1	39.0
1993	36.1	36.5	36.5	36.9	37.3	37.3	37.8	38.1	39.0	40.0
1994	35.7	35.8	36.1	36.3	36.7	36.9	37.3	37.8	38.1	39.0
1995	35.7	35.7	36.0	36.1	36.6	36.9	37.1	37.3	37.8	39.3
1996	35.2	35.4	35.7	35.8	36.2	36.5	36.5	37.1	37.4	38.2
1997	35.1	35.5	35.7	35.9	36.5	36.6	37.1	37.6	38.3	39.0
Median	35.2	35.4	35.7	36.0	36.5	36.7	37.2	37.5	38.1	39.0
Mean	35.4	35.6	35.9	36.1	36.5	36.7	37.1	37.5	38.1	39.1
Std. Error	0.13	0.12	0.11	0.12	0.12	0.11	0.12	0.12	0.14	0.15

Green Sea Turtles

Carapace Width

Strandings of green turtles with carapace widths greater than the currently required minimum TED width openings have not exceeded 2 turtles or 2% of the total measured strandings in any year since 1986 (Table 6).

Body Depth

Strandings of green turtles with body depths greater than the currently required minimum TED height openings has ranged between 1 and 7% of the total measured strandings since 1986 (Table 7). The large turtles are stranding in the Eastern Gulf of Mexico and the Southeast U.S. Atlantic regions, areas of nesting activity.

Examination of the distribution of body depths of the stranded animals indicates that on average 31.4 cm (12.4 in) represents the 97th percentile of the distribution (Table 8). This varies by region, ranging from 15.8 cm (6.2 in) in the N.E. Atlantic to 31.8 cm (12.5 in) in the S.E.U.S. region.

Table 6. Number of Stranded Green Turtles and Percentage of Those Measured with [predicted] Carapace Widths Greater than Currently Required TED Width Openings.

	Region of Stranding										Total	Total
	Western Gulf		Eastern Gulf		SEUS Atlantic		North Atlantic		All Regions		Number	Number
Year	N	%	N	%	N	%	N	%	N	%	Measured	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 7. Number of Stranded Green Turtles and Percentage of Those Measured with Predicted Body Depths Greater than Currently Required TED Height Openings.

	Region of Stranding										Total
	Western Gulf		Eastern Gulf		SEUS Atlantic		North Atlantic		All Regions		Number
Year	N	%	N	%	N	%	N	%	N	%	Measured
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

Table 8. Distribution of Predicted Body Depths (cm) of Stranded Green Turtles from the U.S. Atlantic Seaboard and the Gulf of Mexico.

	PERCENTILE									
YEAR	90	91	92	93	94	95	96	97	98	99
1986	26.1	26.3	26.3	26.8	27.6	31.5	35.3	36.9	39.1	41.0
1987	26.8	27.2	27.2	27.4	30.1	30.2	31.6	31.6	33.6	33.6
1988	20.2	20.4	20.9	21.3	21.6	22.1	22.5	26.1	29.9	33.6
1989	23.2	23.7	23.9	25.1	25.7	27.8	34.4	35.3	36.1	36.5
1990	22.0	22.0	22.5	23.0	23.8	24.9	27.0	34.6	36.8	37.7
1991	22.2	22.5	22.8	23.7	24.2	24.6	26.9	29.2	34.2	36.9
1992	24.1	24.2	25.5	26.5	27.2	28.3	32.8	34.2	35.1	37.9
1993	23.9	25.7	26.9	27.0	27.8	28.1	38.6	29.4	33.6	36.4
1994	22.7	23.7	24.9	26.3	27.0	28.4	29.9	34.0	36.1	37.3
1995	22.0	22.4	23.3	23.7	24.0	24.2	24.2	25.0	25.9	30.4
1996	21.9	22.7	23.0	24.0	24.6	25.7	27.3	30.0	33.9	36.7
1997	20.9	21.5	22.1	24.4	25.0	25.9	29.0	30.7	31.2	35.5
Median	22.5	23.2	23.6	24.7	25.4	26.8	28.8	31.2	34.1	36.6
Mean	23.0	23.5	24.1	24.9	25.7	26.8	29.1	31.4	33.8	36.1
Std. Error	0.57	0.59	0.58	0.55	0.66	0.79	1.13	1.06	1.01	0.77

Kemp's Ridley Sea Turtles

None of the nearly 3000 measured Kemp's ridley turtles which stranded during 1986-1997 (total stranded=3476) had carapace widths or body depths greater than the currently required minimum TED width and height openings.

DISCUSSION

The status of Kemp's ridley and loggerhead sea turtles was evaluated by the NMFS Turtle Expert Working Group (1998; in preparation). Kemp's ridleys constitute a single management unit and the population appears to be increasing. There are four known subpopulations of loggerhead turtles in the Western North Atlantic (Encalada *et al.*, 1998) but only the status of two could be addressed by the TEWG. Nesting of the South Florida subpopulation appears to be increasing, meeting recovery goals set for nesting activity in Florida. The northern subpopulation does not appear to be increasing and may be declining. The status of the Florida Panhandle subpopulation could not be determined, but it is very small. Mortality on at least the northern subpopulation needs to be reduced throughout its range.

Although subpopulations of loggerhead turtles easily can be distinguished on the nesting beaches based on geography, the four subpopulations comingle on the foraging grounds (Rankin-Baransky, 1997; Norrgard, 1995; Bass *et al.*, 1998; Sears *et al.*, 1995; Sears, 1994). At this time, from genetic studies of foraging ground animals and tag recapture data, we know that the benthic animals of the northern subpopulation are distributed along the Atlantic seaboard (*Ibid.*), in Florida Bay (Schroeder, personal communication), and in the Gulf of Mexico (Caldwell *et al.*, 1959; Meylan, 1995). A comprehensive study of the natal origin of stranded loggerheads throughout the Atlantic Coast of North America is ongoing (Schroeder, personal communication).

Eight nesting subpopulations were identified for green turtles in the Atlantic Ocean (Encalada et al., 1996), but later were reduced to 5 regional population units (Bass and Witzell, in review). Like loggerheads, the subpopulations comingle on the foraging grounds (Bass *et al.*, 1998; Lahanas *et al.*, 1998; Bass and Witzell, in review). The status of these subpopulations has not been evaluated quantitatively, but it appears that nesting on the east coast of Florida has been increasing (Meylan et al., 1995; Florida Department of Environmental Protection, unpublished data).

A large proportion of stranded loggerhead turtles and a small proportion of stranded green turtles appear too large to fit through the required minimum-sized TED openings. This is corroborated by analyses of the TEWG (in preparation) which suggest that the size distribution of stranded loggerheads is different (larger) than the size distribution of turtles in the nearshore waters (determined from data on turtles caught in shrimp trawls without TEDs; Gulf & South Atlantic Fisheries Development Foundation, 1998). The relatively large proportion of stranded loggerhead turtles with dimensions greater than the required minimum TED height opening is cause for concern in light of the need to reduce mortality on the northern subpopulation of loggerheads. (TEWG, 1998). Loggerhead turtles are exceeding the minimum required TED height openings before reaching maturity, especially in the Gulf of Mexico where the allowed opening is smaller than in the Atlantic. A reduction in mortality in exactly the size classes not fitting through the TED openings would result in the greatest annual population multiplication rate (Crouse *et al.*, 1987; Heppell, 1998*a*). A reduction in subadult and adult mortality from drowning in trawls would benefit all species and subpopulations of listed sea turtles (Heppell, 1998*b*).

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 be the same in the Gulf of Mexico and the Atlantic. A few of the management options include (1) increasing the dimensions to accommodate some desired proportion of loggerhead turtles currently too large to fit through the existing minimum dimensions, based on strandings data (Table 5); (2) increasing the dimensions to accommodate some desired proportion of the adult loggerheads of the northern subpopulation (Appendix 5); (3) adopting the "leatherback" modification for all areas and all times which would allow the exclusion of turtles of all sizes, including leatherbacks (Federal Register, 1993, 1994, 1995).

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APPENDIX 1. LOGGERHEAD SEA TURTLES

Table 1. Data Sources for Loggerhead Turtle Morphometric Analysis

Source of Data and Contact Person	N	Range of Sizes (cm SCL)
Florida Power and Light, St. Lucie Power Plant, Jonathan Gorham	36	61.2-98.7
Mote Marine Lab, Jerris Foote	12	77.8-101.7
Camp LeJeune Marine Corps Base, John Hammond	11	88.4-109.2
NMFS, Beaufort Laboratory, Joanne Braun McNeill	36	47.8-75.6
NMFS, Galveston Laboratory, Ben Higgins	759	22.7-40.0
Florida Department of Environmental Protection, Allen Foley	74	8.1-102.0

Table 2. Regression of ln carapace width on ln carapace length.

Source	DF	Sum of Squares	Mean Square	F-value
Model	1	44.87501	44.87501	21513.459
Error	248	0.51730	0.00209	
Total	249	45.39231		
Root MSE		0.047567	R-square	0.9886
Dep Mean		3.75319	Adj R-square	0.9886
C.V.		1.21688		

Parameter Estimates	Estimate	Std. Error
Intercept	-0.0225	0.0259
Length	0.9507	0.0065

Table 3. Regression of ln body depth on ln carapace length.

Source	DF	Sum of Squares	Mean Square	F-value
Model	1	41.12154	41.12154	6953.267
Error	248	1.46667	0.00591	
Total	249	42.58821		
Root MSE		0.07690	R-square	0.9656
Dep Mean		3.04614	Adj R-square	0.9654
C.V.		2.52458		

Parameter Estimates	Estimate	Std. Error
Intercept	-0.5682	0.0436
Length	0.9100	0.0109

Figure 1. Regression of Ln Carapace Width on Ln Carapace Length.

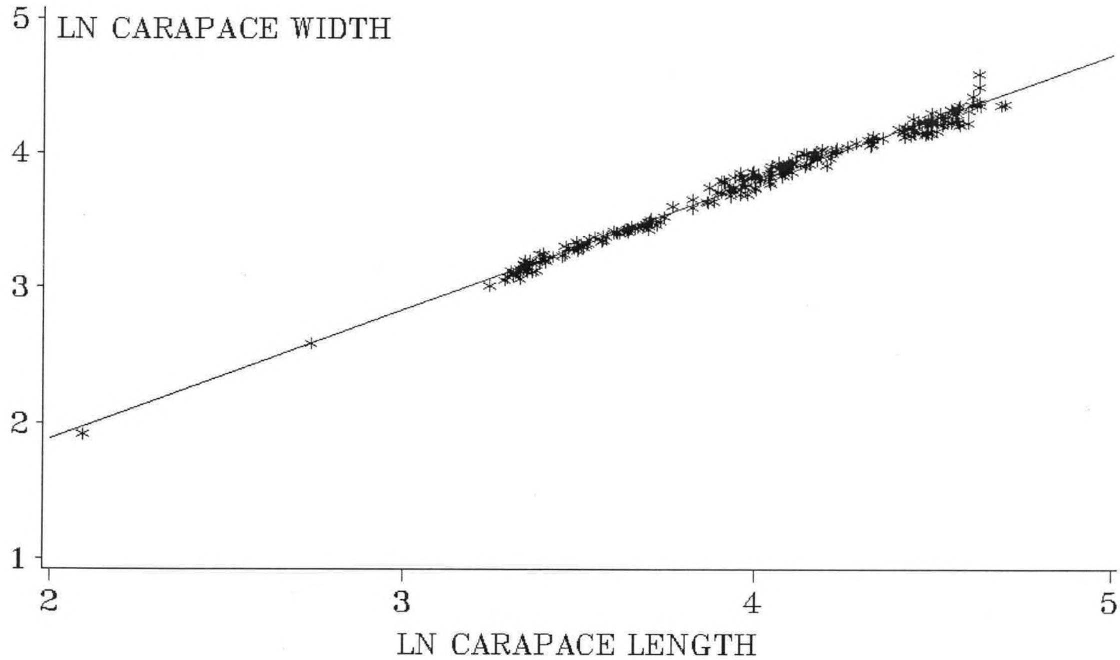


Figure 2. Regression of Ln Body Depth on Ln Carapace Length.

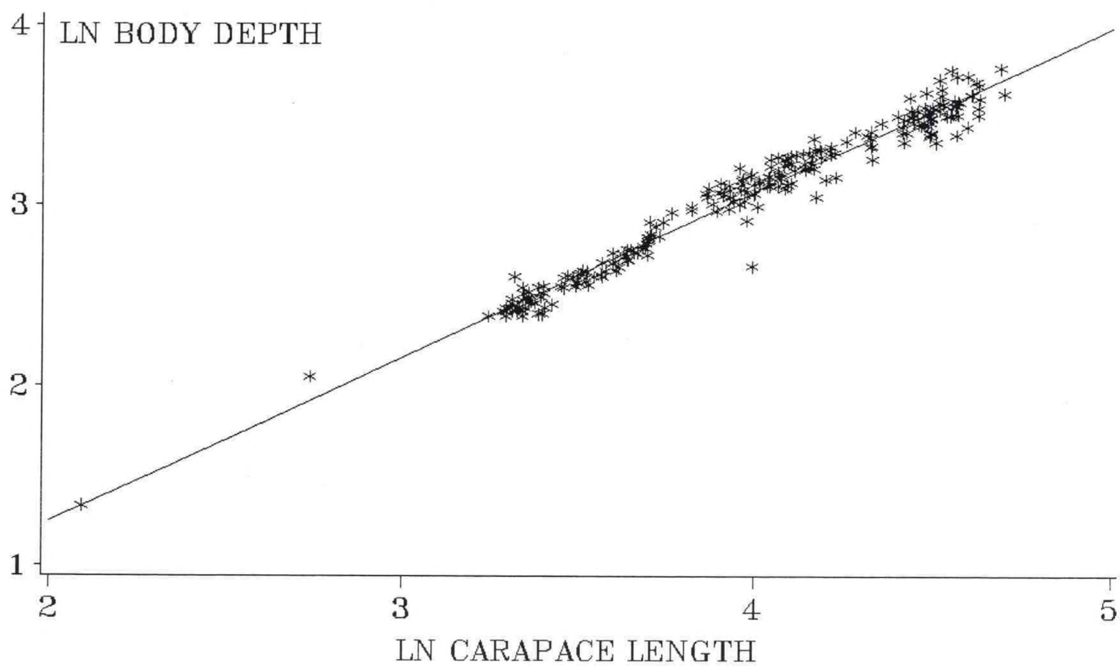


Table 4. Number of Stranded Loggerhead Turtles and Percentage of Those Measured with Body Depths Greater than Currently Required TED Height Openings by Statistical Stranding Zone.

	YEAR OF STRANDING											
	1986		1987		1988		1989		1990		1991	
ZONE	N	%	N	%	N	%	N	%	N	%	N	%
1	0	0	1	100	3	100	11	92	8	80	7	88
2	0	0	0	0	0	0	0	0	1	100	0	0
3	0	0	0	0	0	0	0	0	4	100	2	67
4	18	86	50	98	25	100	89	97	15	88	17	94
5	41	93	40	100	54	98	86	99	33	97	23	96
6	2	100	0	0	6	100	3	75	1	100	3	100
7	1	100	4	100	1	100	1	100	1	50	1	100
8	3	75	4	80	22	85	6	67	9	90	6	86
9	1	100	0	0	1	100	0	0	3	75	0	0
10	1	100	3	75	6	100	5	100	7	88	4	80
11	5	71	14	88	15	94	8	53	9	75	10	71
12	0	0	7	100	1	100	0	0	0	0	0	0
13	1	100	1	100	0	0	0	0	0	0	0	0
14	1	100	0	0	0	50	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0
17	7	28	5	36	0	0	0	0	4	57	2	67
18	19	44	9	45	6	86	4	19	11	31	10	48
19	5	71	10	53	10	53	6	46	9	33	6	55
20	26	48	32	56	32	52	14	48	16	35	9	47
21	9	39	18	64	13	65	17	57	8	44	10	71
24	2	67	2	67	3	75	3	33	6	55	0	0
25	1	20	3	50	3	38	6	43	2	22	3	30
26	9	82	8	50	10	67	12	52	25	86	15	65
27	10	32	15	35	23	35	21	40	38	57	22	40
28	10	29	21	48	26	37	39	36	50	45	26	51
29	24	33	26	28	25	23	23	20	34	25	8	18
30	38	21	34	15	27	16	18	12	17	10	23	17
31	30	31	45	24	19	23	19	28	25	22	16	30
32	34	22	37	18	14	20	9	17	13	23	13	35
33	14	34	18	23	17	33	6	29	16	31	12	55
34	8	26	14	21	10	20	14	23	13	15	10	22
35	7	18	1	3	10	21	9	28	11	15	6	20
36	1	50	1	100	2	29	0	0	0	0	14	52
37	0	0	0	0	1	10	0	0	0	0	0	0
38	0	0	3	43	0	0	1	25	0	0	5	45
39	4	50	7	41	1	20	2	25	4	40	4	50
40	0	0	1	6	2	20	0	0	2	13	3	27
41	0	0	0	0	0	0	1	25	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL TOO DEEP	332	35	434	33	389	38	433	42	395	33	290	39
TOTAL MEASURED	954		1309		1027		1042		1188		734	
TOTAL STRANDED	1209		1728		1373		1425		1592		975	

Table 4. continued

	YEAR OF STRANDING											
	1992		1993		1994		1995		1996		1997	
ZONE	N	%	N	%	N	%	N	%	N	%	N	%
1	5	100	15	88	7	88	5	71	8	89	16	100
2	0	0	0	0	0	0	1	100	1	100	4	100
3	1	100	0	0	1	100	2	100	6	86	9	100
4	21	95	22	96	21	95	18	95	43	93	38	100
5	24	96	22	100	14	100	26	96	32	89	28	93
6	1	100	1	100	1	50	2	100	2	100	1	100
7	2	100	1	50	0	0	1	100	6	100	1	50
8	7	64	7	100	6	67	7	100	12	80	14	82
9	3	43	5	71	5	100	0	0	7	78	6	46
10	2	67	0	0	5	100	4	67	2	100	10	67
11	0	0	3	50	4	57	0	0	8	73	4	67
12	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	1	33	2	100	2	50	1	100
14	1	33	1	100	0	0	0	0	2	100	4	100
15	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	1	100	0	0	1	50	0	0
18	5	45	5	42	16	48	9	45	27	51	22	65
19	4	44	7	58	32	70	12	38	14	39	22	71
20	22	69	9	43	40	57	18	58	44	57	39	67
21	3	60	4	44	7	41	15	68	9	60	9	56
24	8	80	4	44	4	80	3	60	3	75	7	58
25	3	50	5	38	6	75	4	50	3	27	10	59
26	13	59	13	59	15	58	4	36	17	74	8	30
27	48	63	24	51	31	62	29	58	41	58	17	40
28	31	61	37	61	45	51	38	52	50	41	24	38
29	13	27	20	54	10	20	18	30	24	26	15	21
30	13	11	6	11	18	15	10	12	15	12	8	6
31	8	22	22	42	31	40	16	20	21	27	9	17
32	15	45	19	44	10	24	13	23	17	20	17	20
33	9	27	11	26	21	38	14	23	20	27	11	27
34	8	14	10	20	12	24	4	7	10	8	12	14
35	15	25	7	41	23	30	35	36	20	19	19	18
36	21	44	4	29	18	41	19	49	22	28	22	18
37	0	0	1	100	1	6	0	0	3	8	4	7
38	4	80	4	50	4	18	6	26	11	44	11	35
39	2	22	4	31	1	7	7	18	7	21	2	15
40	0	0	3	33	2	13	5	22	2	17	4	24
41	0	0	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL TOO DEEP	312	41	296	47	413	41	347	36	512	36	428	34
TOTAL MEASURED	763		636		1010		956		1436		1266	
TOTAL STRANDED	1101		972		1342		1424		1883		1643	

APPENDIX 2. GREEN SEA TURTLES

Table 1. Data Sources for Green Turtle Morphometric Analysis.

Source of Data and Contact Person	N	Range of Sizes (cm SCL)
Florida Power and Light, St. Lucie Power Plant, Jonathan Gorham	1	55.1
NMFS, Beaufort Laboratory, Joanne Braun McNeill	9	42.4-53.2
Cayman Turtle Farm, Joe Parsons	27	49.1-117.5
NMFS, SEFSC, Wendy Teas	4	58.4-65.6
Florida Department of Environmental Protection, Allen Foley	114	16.0-106.0
Florida Atlantic University, Jeanette Wyneken	21	3.2-10.8

Table 2. Regression of ln carapace width on ln carapace length.

Source	DF	Sum of Squares	Mean Square	F-value
Model	1	88.15237	88.15237	33660.661
Error	174	0.45568	0.00262	
Total	175	88.60805		

Root MSE	0.05117	R-square	0.9949
Dep Mean	3.24703	Adj R-square	0.9948
C.V.	1.57605		

Parameter Estimates	Estimate	Std. Error
Intercept	-0.1607	0.0190
Length	0.9812	0.0053

Table 3. Regression of ln body depth on ln carapace length.

Source	DF	Sum of Squares	Mean Square	F-value
Model	1	91.98555	91.98555	7515.668
Error	174	2.12962	0.01224	
Total	175	94.11517		

Root MSE	0.11063	R-square	0.9774
Dep Mean	2.46967	Adj R-square	0.9772
C.V.	4.47958		

Parameter Estimates	Estimate	Std. Error
Intercept	-1.0115	0.0410
Length	1.0023	0.0116

Figure 1. Regression of Ln Carapace Width on Ln Carapace Length.

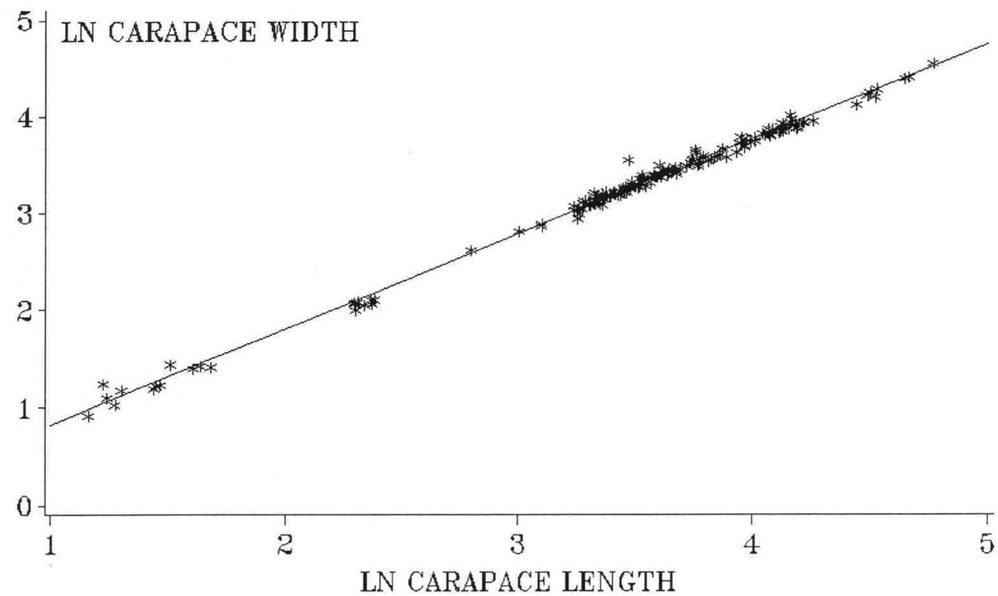


Figure 2. Regresson of Ln Body Depth on Ln Carapace Length.

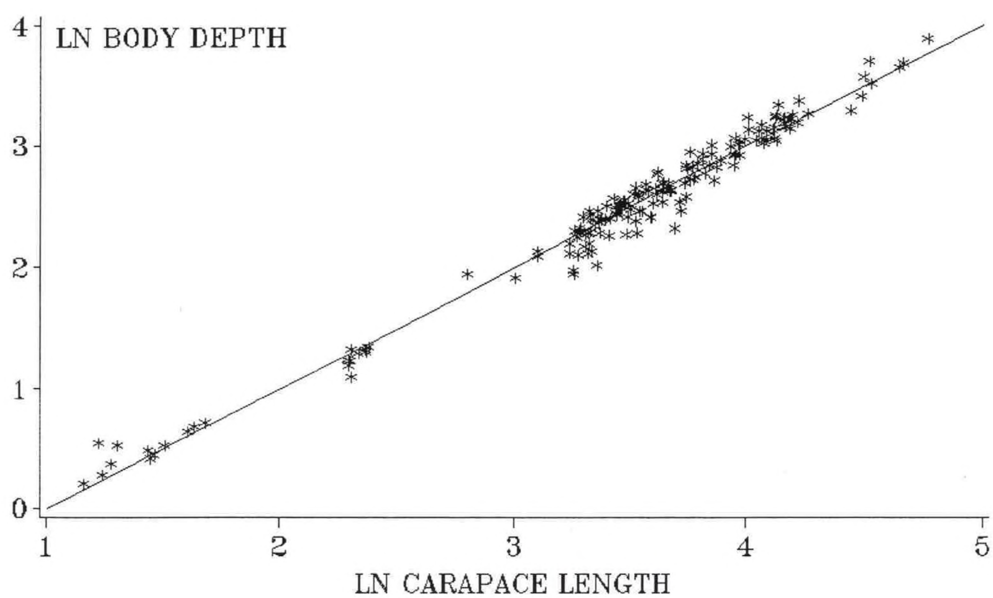


Table 4. Number of Stranded Green Turtles and Percentage of Those Measured with Body Depths Greater than Currently Required TED Height Openings by Statistical Stranding Zone.

	YEAR OF STRANDING											
	1986		1987		1988		1989		1990		1991	
ZONE	N	%	N	%	N	%	N	%	N	%	N	%
1	0	0	1	11	1	10	0	0	1	3	1	10
2	0	0	0	0	0	0	0	0	0	0	0	0
3	1	100	0	0	0	0	0	0	0	0	0	0
4	0	0	1	50	0	0	1	100	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	1	100	0	0	0	0
8	1	100	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	1	100	0	0	0	0
10	0	0	0	0	1	100	0	0	0	0	0	0
11	1	50	1	25	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	1	100	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	1	33	0	0	0	0
19	2	100	1	100	1	100	1	50	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	1	25	0	0	0	0
24	0	0	1	7	0	0	0	0	0	0	0	0
25	0	0	0	0	1	14	0	0	0	0	0	0
26	2	8	1	5	0	0	6	19	7	17	1	3
27	0	0	1	4	0	0	0	0	1	1	1	1
28	1	13	0	0	0	0	0	0	1	6	1	10
29	0	0	0	0	1	33	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	0	0	0	0
36	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0	0	0
41	0	0	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL TOO DEEP	7	7	8	7	5	3	12	5	10	4	6	3
TOTAL MEASURED	100		122		177		219		277		196	
TOTAL STRANDED	125		142		193		255		308		221	

Table 4. continued

	YEAR OF STRANDING											
	1992		1993		1994		1995		1996		1997	
ZONE	N	%	N	%	N	%	N	%	N	%	N	%
1	2	25	3	14	2	22	0	0	5	28	2	18
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	1	50	0	0	0	0	0	0
4	0	0	1	25	0	0	0	0	3	15	0	0
5	0	0	0	0	0	0	0	0	1	2	1	8
6	0	0	0	0	0	0	1	6	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	1	100	0	0	1	100	0	0
10	0	0	0	0	0	0	0	0	0	0	1	100
11	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	1	9	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	1	3	1	6
21	0	0	0	0	0	0	0	0	0	0	0	0
24	0	0	0	0	1	14	0	0	0	0	0	0
25	2	22	4	36	0	0	2	9	1	4	2	9
26	3	13	0	0	4	15	1	5	1	2	2	6
27	3	5	0	0	2	3	0	0	4	3	1	2
28	0	0	0	0	1	6	0	0	3	14	0	0
29	0	0	0	0	1	17	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0
33	0	0	0	0	0	0	0	0	0	0	1	25
34	0	0	0	0	0	0	0	0	0	0	0	0
35	0	0	0	0	0	0	0	0	1	4	1	5
36	0	0	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	0
40	0	0	1	100	0	0	0	0	0	0	0	0
41	0	0	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL TOO DEEP	10	6	9	5	14	5	4	1	21	4	12	4
TOTAL MEASURED	180		175		258		301		500		282	
TOTAL STRANDED	208		200		320		389		584		352	

APPENDIX 3. KEMP'S RIDLEY SEA TURTLES

Table 1. Data Sources for Kemp's Ridley Turtle Morphometric Analysis.

Source of Data and Contact Person	N	Range of Sizes (cm SCL)
NMFS, SEFSC, Wendy Teas	2	53.6-57.7
NMFS, SEFSC, Jeffrey Schmid	243	26.8-58.5
NMFS, Galveston Laboratory, Tim Fontaine	6964	3.8-59.6
Florida Department of Environmental Protection, Allen Foley	2	38.6-59.6
Cayman Turtle Farm, Joe Parsons	20	46.5-59.5

Table 2. Regression of ln carapace width on ln carapace length.

Source	DF	Sum of Squares	Mean Square	F-value
Model	1	378.69109	378.69109	307363.482
Error	629	0.77497	0.00123	
Total	630	379.46606		

Root MSE	0.03510	R-square	0.9980
Dep Mean	3.02605	Adj R-square	0.9980
C.V.	1.15995		

Parameter Estimates	Estimate	Std. Error
Intercept	-0.2039	0.0060
Length	1.0437	0.0019

Table 3. Regression of ln body depth on ln carapace length.

Source	DF	Sum of Squares	Mean Square	F-value
Model	1	286.33626	286.33626	56002.923
Error	629	3.21600	0.00511	
Total	630	289.55226		

Root MSE	0.07150	R-square	0.9889
Dep Mean	2.18029	Adj R-square	0.9889
C.V.	3.27958		

Parameter Estimates	Estimate	Std. Error
Intercept	-0.6283	0.0122
Length	0.9075	0.0038

Figure 1. Regression of Ln Carapace Width on Ln Carapace Length.

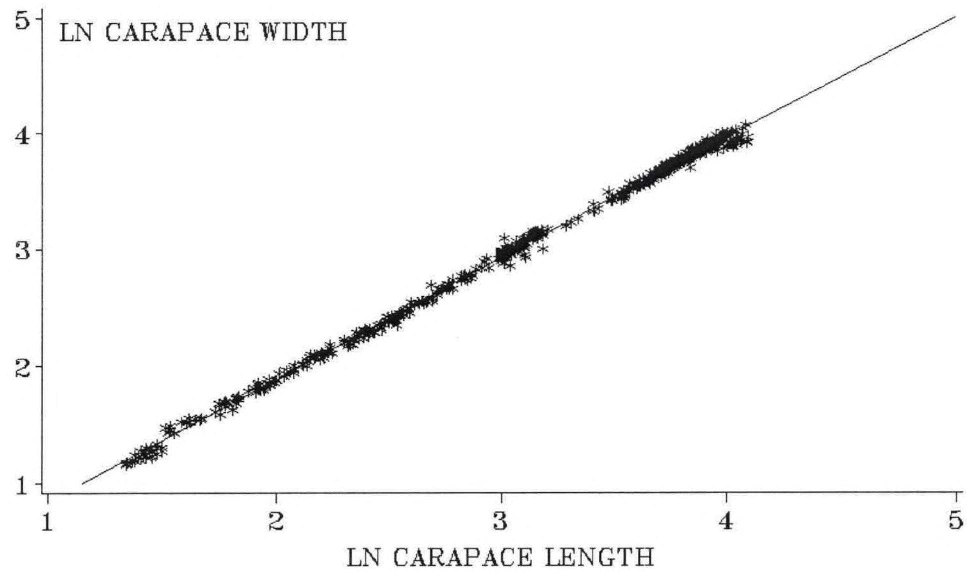
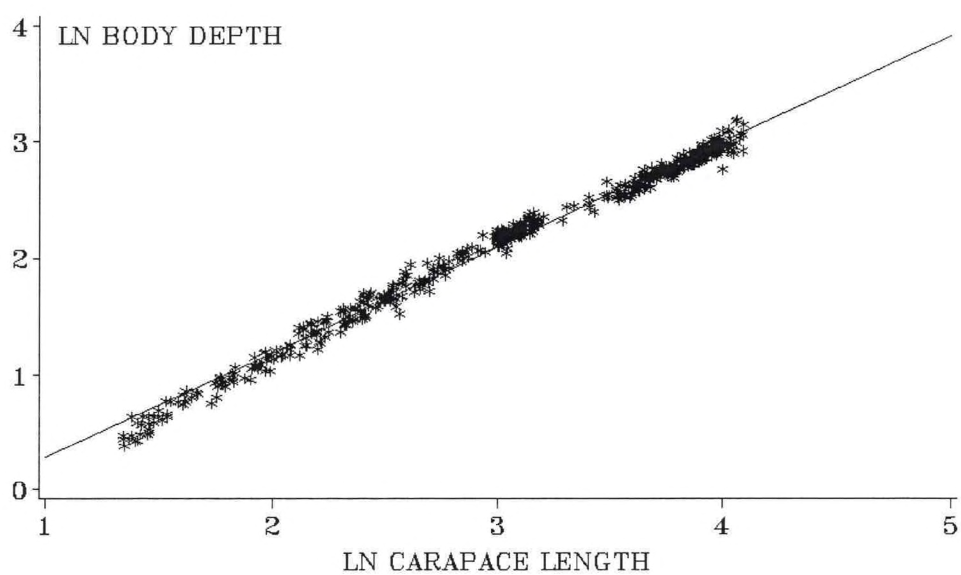


Figure 2. Regression of Ln Body Depth on Ln Carapace Length.



APPENDIX 4. PREDICTED MORPHOMETRICS

Table 1. Predicted Straight Carapace Widths (cm SCW) and Body Depths (cm BD) of Loggerhead, Green, and Kemp's Ridley Sea Turtles, 5-125 cm SCL.

	Loggerhead		Green		Kemp's Ridley	
SCL	SCW	BD	SCW	BD	SCW	BD
5	4.5	2.4	4.1	1.8	4.4	2.3
6	5.3	2.9	4.9	2.2	5.3	2.7
7	6.1	3.3	5.7	2.6	6.2	3.1
8	7.0	3.7	6.6	2.9	7.1	3.5
9	7.8	4.2	7.4	3.3	8.1	3.9
10	8.6	4.6	8.2	3.7	9.0	4.3
11	9.5	5.0	9.0	4.0	10.0	4.7
12	10.3	5.4	9.8	4.4	10.9	5.1
13	11.1	5.8	10.5	4.8	11.9	5.5
14	11.9	6.2	11.3	5.1	12.8	5.9
15	12.7	6.6	12.1	5.5	13.8	6.2
16	13.5	7.0	12.9	5.9	14.7	6.6
17	14.3	7.4	13.7	6.2	15.7	7.0
18	15.1	7.8	14.5	6.6	16.7	7.4
19	15.9	8.2	15.3	7.0	17.6	7.7
20	16.7	8.6	16.1	7.3	18.6	8.1
21	17.5	9.0	16.9	7.7	19.6	8.5
22	18.3	9.4	17.7	8.1	20.5	8.8
23	19.1	9.8	18.5	8.4	21.5	9.2
24	19.9	10.2	19.3	8.8	22.5	9.5
25	20.7	10.6	20.0	9.2	23.5	9.9
26	21.5	10.9	20.8	9.5	24.4	10.3
27	22.3	11.3	21.6	9.9	25.4	10.6
28	23.1	11.7	22.4	10.3	26.4	11.0
29	23.9	12.1	23.2	10.6	27.4	11.3
30	24.7	12.5	24.0	11.0	28.4	11.7
31	25.5	12.9	24.7	11.4	29.4	12.0
32	26.2	13.2	25.5	11.7	30.4	12.4
33	27.0	13.6	26.3	12.1	31.4	12.7
34	27.8	14.0	27.1	12.5	32.3	13.1
35	28.6	14.4	27.9	12.8	33.3	13.4
36	29.4	14.7	28.7	13.2	34.3	13.8
37	30.1	15.1	29.4	13.6	35.3	14.1
38	30.9	15.5	30.2	13.9	36.3	14.5
39	31.7	15.9	31.0	14.3	37.3	14.8
40	32.5	16.2	31.8	14.7	38.3	15.2
41	33.3	16.6	32.6	15.0	39.3	15.5
42	34.0	17.0	33.3	15.4	40.3	15.9
43	34.8	17.3	34.1	15.8	41.3	16.2
44	35.6	17.7	34.9	16.1	42.3	16.5
45	36.3	18.1	35.7	16.5	43.3	16.9
46	37.1	18.4	36.5	16.9	44.3	17.2
47	37.9	18.8	37.2	17.2	45.4	17.6
48	38.7	19.2	38.0	17.6	46.4	17.9
49	39.4	19.5	38.8	18.0	47.4	18.2
50	40.2	19.9	39.6	18.4	48.4	18.6

Table 1. continued

	Loggerhead		Green		Kemp's Ridley	
SCL	SCW	BD	SCW	BD	SCW	BD
51	41.0	20.3	40.3	18.7	49.4	18.9
52	41.7	20.6	41.1	19.1	50.4	19.3
53	42.5	21.0	41.9	19.5	51.4	19.6
54	43.3	21.4	42.7	19.8	52.4	19.9
55	44.0	21.7	43.4	20.2	53.4	20.3
56	44.8	22.1	44.2	20.6	54.5	20.6
57	45.6	22.4	45.0	20.9	55.5	20.9
58	46.3	22.8	45.8	21.3	56.5	21.3
59	47.1	23.2	46.5	21.7	57.5	21.6
60	47.9	23.5	47.3	22.0	58.5	21.9
61	48.6	23.9	48.1	22.4	59.5	22.3
62	49.4	24.2	48.9	22.8	60.6	22.6
63	50.1	24.6	49.6	23.1	61.6	22.9
64	50.9	24.9	50.4	23.5	62.6	23.2
65	51.7	25.3	51.2	23.9	63.6	23.6
66	52.4	25.7	51.9	24.2	64.6	23.9
67	53.2	26.0	52.7	24.6	65.7	24.2
68	53.9	26.4	53.5	25.0	66.7	24.6
69	54.7	26.7	54.3	25.3	67.7	24.9
70	55.4	27.1	55.0	25.7	68.7	25.2
71	56.2	27.4	55.8	26.1		
72	57.0	27.8	56.6	26.4		
73	57.7	28.1	57.3	26.8		
74	58.5	28.5	58.1	27.2		
75	59.2	28.8	58.9	27.6		
76	60.0	29.2	59.7	27.9		
77	60.7	29.5	60.4	28.3		
78	61.5	29.9	61.2	28.7		
79	62.2	30.2	62.0	29.0		
80	63.0	30.6	62.7	29.4		
81	63.8	30.9	63.5	29.8		
82	64.5	31.3	64.3	30.1		
83	65.3	31.6	65.0	30.5		
84	66.0	32.0	65.8	30.9		
85	66.8	32.3	66.6	31.2		
86	67.5	32.7	67.4	31.6		
87	68.3	33.0	68.1	32.0		
88	69.0	33.4	68.9	32.3		
89	69.8	33.7	69.7	32.7		
90	70.5	34.1	70.4	33.1		
91	71.3	34.4	71.2	33.4		
92	72.0	34.8	72.0	33.8		
93	72.8	35.1	72.7	34.2		
94	73.5	35.4	73.5	34.6		
95	74.2	35.8	74.3	34.9		

Table 1. continued

	Loggerhead		Green		Kemp's Ridley	
SCL	SCW	BD	SCW	BD	SCW	BD
96	75.0	36.1	75.0	35.3		
97	75.7	36.5	75.8	35.7		
98	76.5	36.8	76.6	36.0		
99	77.2	37.2	77.3	36.4		
100	78.0	37.5	78.1	36.8		
101	78.7	37.9	78.9	37.1		
102	79.5	38.2	79.6	37.5		
103	80.2	38.5	80.4	37.9		
104	81.0	38.9	81.2	38.2		
105	81.7	39.2	81.9	38.6		
106	82.4	39.6	82.7	39.0		
107	83.2	39.9	83.5	39.3		
108	83.9	40.2	84.2	39.7		
109	84.7	40.6	85.0	40.1		
110	85.4	40.9	85.8	40.4		
111	86.2	41.3	86.5	40.8		
112	86.9	41.6	87.3	41.2		
113	87.6	41.9	88.0	41.6		
114	88.4	42.3	88.8	41.9		
115	89.1	42.6	89.6	42.3		
116	89.9	43.0	90.3	42.7		
117	90.6	43.3	91.1	43.0		
118	91.3	43.6	91.9	43.4		
119	92.1	44.0	92.6	43.8		
120	92.8	44.3	93.4	44.1		
121	93.6	44.6	94.2	44.5		
122	94.3	45.0	94.9	44.9		
123	95.0	45.3	95.7	45.2		
124	95.8	45.7	96.5	45.6		
125	96.5	46.0	97.2	46.0		

APPENDIX 5. SIZE DISTRIBUTION OF NESTING NORTHERN SUBPOPULATION LOGGERHEAD TURTLES

Table 1. Data Sources for Size Distribution Information of Nesting Loggerhead Turtles.

State	Beach	Years	N	Range (cm SCL)	Mean	Std Dev	Source
NC	Baldhead Island	1998	33	79.5-103.5	92.4	5.6	Brannon Quel
	Bear Island	1990-1999	91	78.2-108.5	97.7	5.8	Sam Bland
	Cape Lookout	1977-1983	65	77.7-105.2	94.3	5.5	Mike Rikard
	Onslow Beach	1990-1995	40	82.8-112.9	93.9	5.7	John Hammond
SC	South Island	1978-1979;	92	82.8-111.7	93.6	5.2	Tom Murphy
		1986-1989;					
		1994, 1996					
GA	Jekyll Island	1991-1995;	181	81.0-106.6	93.2	5.2	Mark Dodd
		1997-1998					
	Wassaw Beach	1991-1998	295	80.1-108.1	93.7	4.7	Kris Wiliams
	Summary		797	77.7-112.9	94.1	5.3	

Table 2. Distribution of Sizes (cm SCL) of Nesting Loggerhead Turtles of the Northern Subpopulation and Estimated Straight Carapace Widths (cm SCW) and Body Depths (cm BD).

	SCL	SCW	BD
Percentile		(cm)	
10	87.7	68.7	33.2
20	89.6	70.2	33.9
25	90.5	70.9	34.2
30	91.3	71.4	34.4
40	92.4	72.3	34.8
50	94.3	73.7	35.5
60	95.3	74.4	35.8
70	96.5	75.3	36.2
75	97.3	75.9	36.5
80	98.5	76.8	36.9
90	100.9	78.6	37.8
91	101.9	79.3	38.1
92	101.9	79.3	38.1
93	102.1	79.5	38.2
94	102.8	80.0	38.4
95	102.8	80.0	38.4
96	103.8	80.7	38.7
97	104.7	81.4	39.0
98	104.7	81.4	39.0
99	107.1	83.2	39.8