Analysis of Sea Turtle Captures and Mortalities Aboard Commercial Shrimp Trawling Vessels

DRAFT

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ABSTRACT

Commercial shrimp trawling in the Gulf of Mexico and south Atlantic has been identified as a major source of sea turtle captures and mortalities. To quantify the impact of the shrimp fishery on sea turtle stocks, all NMFS observer data collected aboard shrimp trawlers (1973 to 1984) were merged and analyzed. Estimates of catch per unit effort (CPUE) and mortality by species, season, depth and area were developed. In the Gulf of Mexico, CPUE for all species combined is estimated to be 0.0031±0.0008 turtles/30.5-m net hour and for the southeastern Atlantic estimates are 0.0487±0.0041 turtles/30.5-m net hour. The Gulf mortality rate for turtles captured in trawls is 29 percent and the Atlantic coast rate is 21 percent. Based on these analyses, we estimate that as many as 11,000 turtles (10,000 loggerheads, 800 ridleys, and 300 greens) may be drowned annually as a result of trawling activities.

INTRODUCTION

The incidental capture of sea turtles by commercial shrimp trawlers has been identified as a source of turtle mortalities in the South Atlantic and the Gulf of Mexico (Hopkins and Richardson 1984). Several studies have attempted to quantify turtle catch rates and mortalities aboard trawlers through interviews with vessel captains (Anon 1976, Anon 1977, Cox and Mauerman 1976, Rabalais and Rabalais 1980) or through direct observations by fisheries observers aboard commercial vessels (Hillestad et al 1978, Ulrich 1978, Roithmayr and Henwood unpubl). While these studies provide preliminary estimates of capture and mortality rates, more specific information is required to effectively manage the stocks. In particular, managers need to know when and where turtle captures occur, which species are impacted, at what depths the majority of captures occur and how many turtles are killed.

The purpose of this report is to provide a current analysis of existing data collected by fisheries observers aboard commercial shrimp trawlers from 1973 through 1984. Observer data provide the best estimate

of catch rates on the shrimping grounds because actual turtle captures during normal trawling activities are recorded. It is assumed that capture rates and mortalities from observer data reflect those of the fleet as a whole.

DATA ANALYSES

The sea turtle data base maintained by the National Marine Fisheries Service (NMFS) Pascagoula Laboratory contains 4649 records of turtles captured primarily by trawling. Records also include recaptures of tagged turtles, beach strandings and several other sources of capture not related to trawling. We used this data base to address the question of where sea turtles occur.

To address the remaining questions, three observer projects were merged for analysis of turtle catch per unit effort (CPUE) and mortality rates. A brief description of each project objectives and methodologies follows:

1) The sea turtle incidental catch and mortality project was instituted to provide information

on the incidental capture and associated mortality of sea turtles off the southeastern United States. Trained fisheries observers were placed aboard commercial shrimp vessels operating on the major grounds in the Gulf and South Atlantic. For each tow, turtle captures and associated biological data were recorded on stations sheets. The total effort was 10,905 hr; 318 turtles were captured. Data were collected from 1979 through 1981.

2) The goal of the excluder trawl project was to design an apparatus for use with existing shrimping gear which would effectively prevent the incidental capture of sea turtles. Initial design and testing of prototype models was conducted during 1977, and field trials continued through 1984. Trained fisheries observers aboard cooperative and chartered shrimp trawlers began data collection in 1978. Data collection procedures were similar to those of the incidental catch project except that a station sheet was completed for each net. In this manner the performance of excluder nets could be compared with that of

standard trawls. For the present analyses, only turtle captures and effort from standard nets were considered. The total effort was 14,056 hr; 563 turtles were captured.

3) The objectives of the shrimp fleet discards project were to estimate the magnitude and species composition of incidental fish captures by the Gulf shrimp fleet. Data were collected through contractual arrangements with state agencies from 1973 through 1978. These agencies placed observers on commercial vessels to obtain at-sea sampling off their respective coasts. Station sheets similar to those of the other two projects were completed for each tow. The total effort in this project was 2,617 hr and 3 turtles were captured.

For each data set, effort (E) was standardized to reflect hours towed with a single 30.5-m headrope length net using the formula:

$$E = (\text{nets} * \text{length} / 30.5) * (\text{mins} / 60)$$

where

nets = number of nets towed

length = headrope length of the net (meters), and

mins = minutes fished.

CPUE and the 95% c.i. on CPUE was calculated according to methods described in Snedecor and Cochran (1962) using the formulae:

$$R = \Sigma Y / \Sigma X$$

$$95\% \text{ c.i. on } R = R \pm 1.96 \left(1 / \bar{X} \right) \sqrt{\frac{\Sigma (Y - RX)^2}{n\,(n-1)}}$$

where

R = CPUE

Y = number of turtles

X = effort (standardized to 30.5 net hrs)

n = number of tows

The data were separated by species, season, depth and statistical zone (corresponding to those used in reporting shrimp landings). For each zone turtle CPUE, mean depth of capture, mean length of tow and mortality were then computed. In summarizing the data, the Gulf

of Mexico was subdivided into Eastern (zones 1-7), Central (zones 8-17) and Western (zones 18-21) (Fig. 1). The Atlantic area included zones 24-33 and part of zone 28. The Cape Canaveral ship channel and adjacent shrimping grounds (28° $15'$ to 28° $30'$) was omitted (Fig. 2) to avoid biasing estimates because turtle catch rates were extremely high (0.3643 $\pm$ 0.0045 turtles/hr). These catch rates do not reflect those occurring on the shrimping grounds outside the Canaveral area.

Estimates of shrimp fishing effort for the offshore Gulf of Mexico shrimp fishery were obtained from the NMFS Galveston Laboratory. The shrimp fishing effort was corrected for relative amounts of effort by the different sectors of the offshore fishery (Table 1) and then standardized to 30.5-m trawling hours (Table 2). The Atlantic shrimp fishing effort was based on an effort estimate developed in 1983 (Anon 1983). Because the data were being updated, more current Atlantic shrimp fishing effort data were unavailable at this time.

Mortality rates (Y) were estimated by substituting the average minutes fished (X) for specific areas into

a formula ($Y = 0.00165X - 0.03$). This formula was derived from the least squares linear regression of percent mortality on minutes fished using 4624 turtle captures (Fig. 13). The average mortality over 30 minute increments of tow length was calculated and ten unweighted means were regressed on minutes fished. Although this approach violates the assumption of homogeneity in regression, it was determined to be the most appropriate means of describing this relationship. Percent mortality was then multiplied by the 95% upper and lower confidence bounds of turtle captures to estimate the number of turtles killed.

RESULTS AND DISCUSSION

Locations of all turtle captures in the Gulf of Mexico and South Atlantic were plotted by species (Figs. 3-12). These plots reflect turtle captures from all sources. In computing CPUE and mortality rates, several of these captures were omitted because no associated trawling effort was available.

Turtle captures and mortality by statistical zone and season for each species with associated effort data are presented in Tables 3-8. While the total observer effort in the Gulf of Mexico (16,785 hr) was greater than the South Atlantic (9,943 hr), 484 turtles were captured in the South Atlantic and only 52 were captured in the Gulf of Mexico. This indicates that per unit effort, sixteen turtles are captured in the Atlantic for every one turtle captured in the Gulf.

The mean depth of fishing and mean length of tow were computed from effort data for each statistical zone (Table 9) and for tows in which loggerhead, ridley and green turtles were captured (Tables 10-12). The 95% confidence intervals for mean depth and minutes fished from turtle capture data were compared with

those from effort data and instances of non-overlap of c.i. were noted. In most cases (particularly the Gulf of Mexico) sample sizes were small making interpretation difficult. We suggest that despite apparent statistical differences, average depth and tow duration of turtle captures were probably not different from that of the effort.

Summary information on observer effort, CPUE, shrimping effort, estimated captures and estimated mortality in the Gulf of Mexico and South Atlantic are presented for each species (Tables 13-17). Results indicated the CPUE for all turtles in the Gulf of Mexico (zones 1-21) was 0.0031 ± 0.0008 turtles/30.5-m net hour, and CPUE for the southeastern Atlantic (zones 24-33) was 0.0487 ± 0.0041 turtles/30.5-m net hour.

The calculation of estimated mortality used the minutes fished as a means of estimating the percent of the turtles captured that are killed (see Figure 13 and minutes fished in Table 10). Based on these data, the overall mortality rate for the Gulf of Mexico is 29 percent. The eastern Gulf mortality rate is 34 percent, the central Gulf rate is 22 percent and the western Gulf rate is 38 percent. For the Atlantic

coast the rate is 21 percent reflecting the shorter average duration of trawl tows on the Atlantic coast.

The mortality rates based on minutes fished do not distinguish among species. This is due to the small numbers of captures for species other than loggerhead turtles. If there are differences in the ability of the other turtle species to survive long periods of immersion and the stress involved in being captured in a trawl, the differences will not be evident in this analysis.

The CPUE for all turtles is strongly dependent on depth (Figures 14-16). In depths greater than 10 fathoms turtle captures are rare, even though, based on aerial surveys (Nancy Thompson)[1], turtles are distributed well offshore in waters considerably deeper than 10 fathoms. The low CPUE is probably due to the fact that our data come entirely from bottom trawls, and the majority of our effort was in depths of less than 10 fathoms.

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[1]Nancy Thompson, SEFC, NMFS, Miami Laboratory, 75 Virginia Beach Drive, Miami, FL 33149. Pers. Commun.

CONCLUSIONS

From our analyses it is evident that significant numbers of sea turtles are captured by commercial trawlers in both the Gulf of Mexico and the South Atlantic, and that over 20 percent of these turtles are drowned in the trawl. As many as 10,000 loggerheads, *Caretta caretta*, 800 ridleys, *Lepidochelys kempi*, and 300 green turtles, *Chelonia mydas*, may be killed annually.

These levels of accidental mortality are unacceptably high and represent a major barrier to the recovery of the species. In the case of the Kemp's ridley where only 500-600 females are known to nest annually, this source of mortality, if continued, could result in the extirpation of the species.

ACKNOWLEDGEMENTS

We thank all individuals who participated in the collection of data aboard commercial vessels and those persons who managed each of the projects. In particular, we wish to acknowledge the contributions of Frederick Berry, Andrew Kemmerer, Walter Nelson, Wilber Seidel, John Watson, Charles McVea, Charles Roithmayr and Butch Pellegrin. Rick Minkler and Mark McDuff provided computer programming support; Velda Harris secretarial support.

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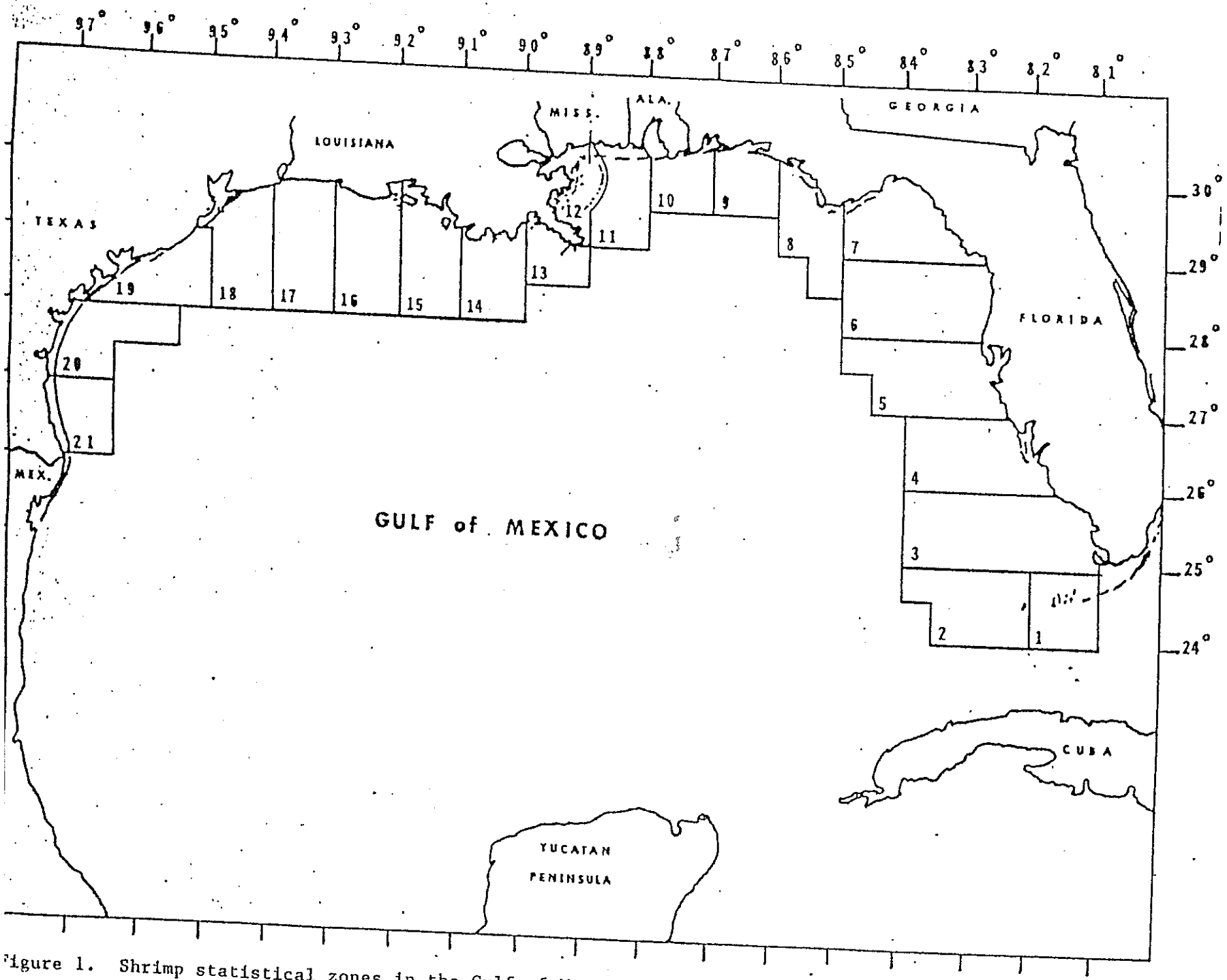

Figure 1. Shrimp statistical zones in the Gulf of Mexico

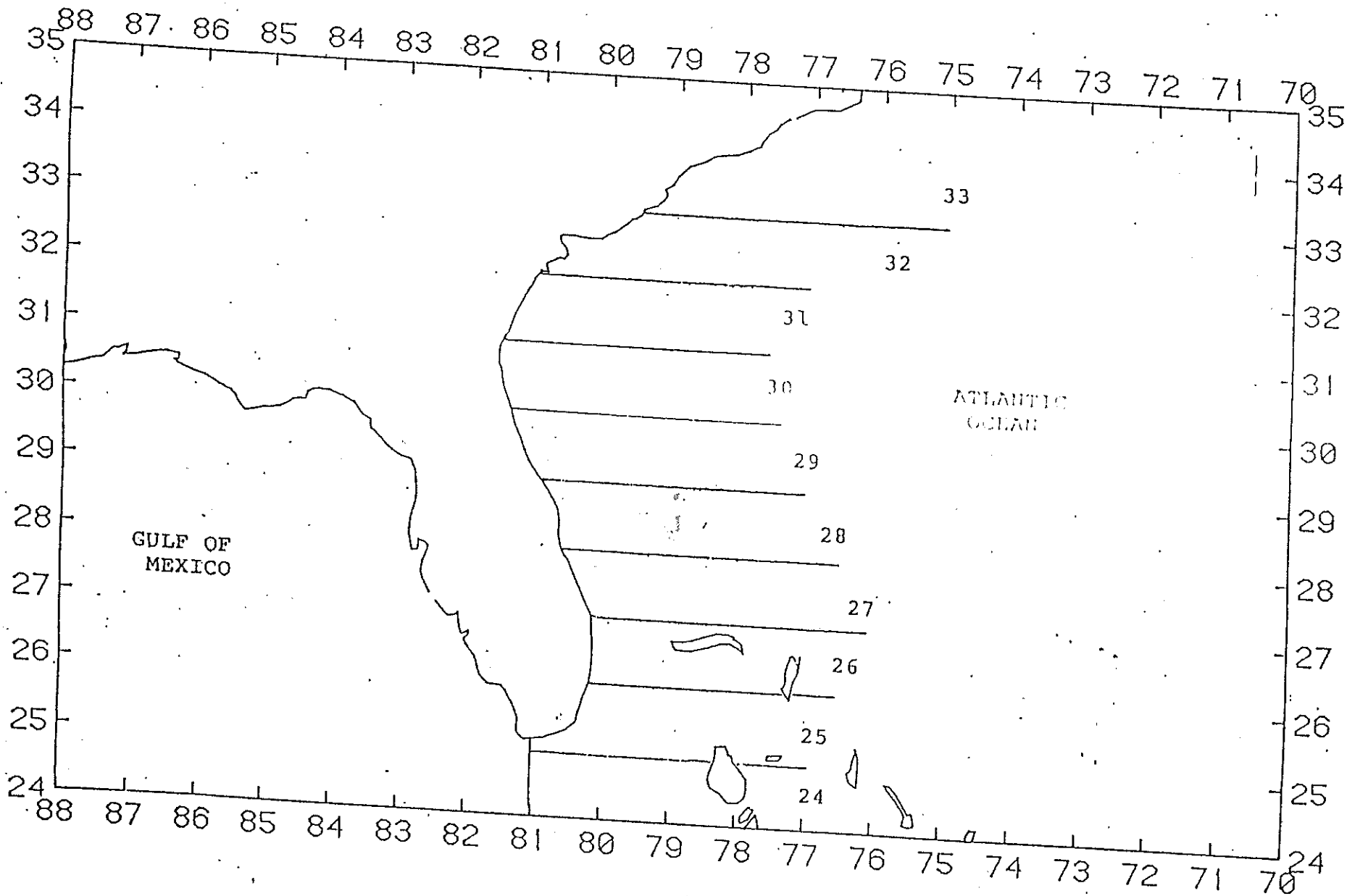

Figure 2. Statistical zones off the southeastern Atlantic coast.

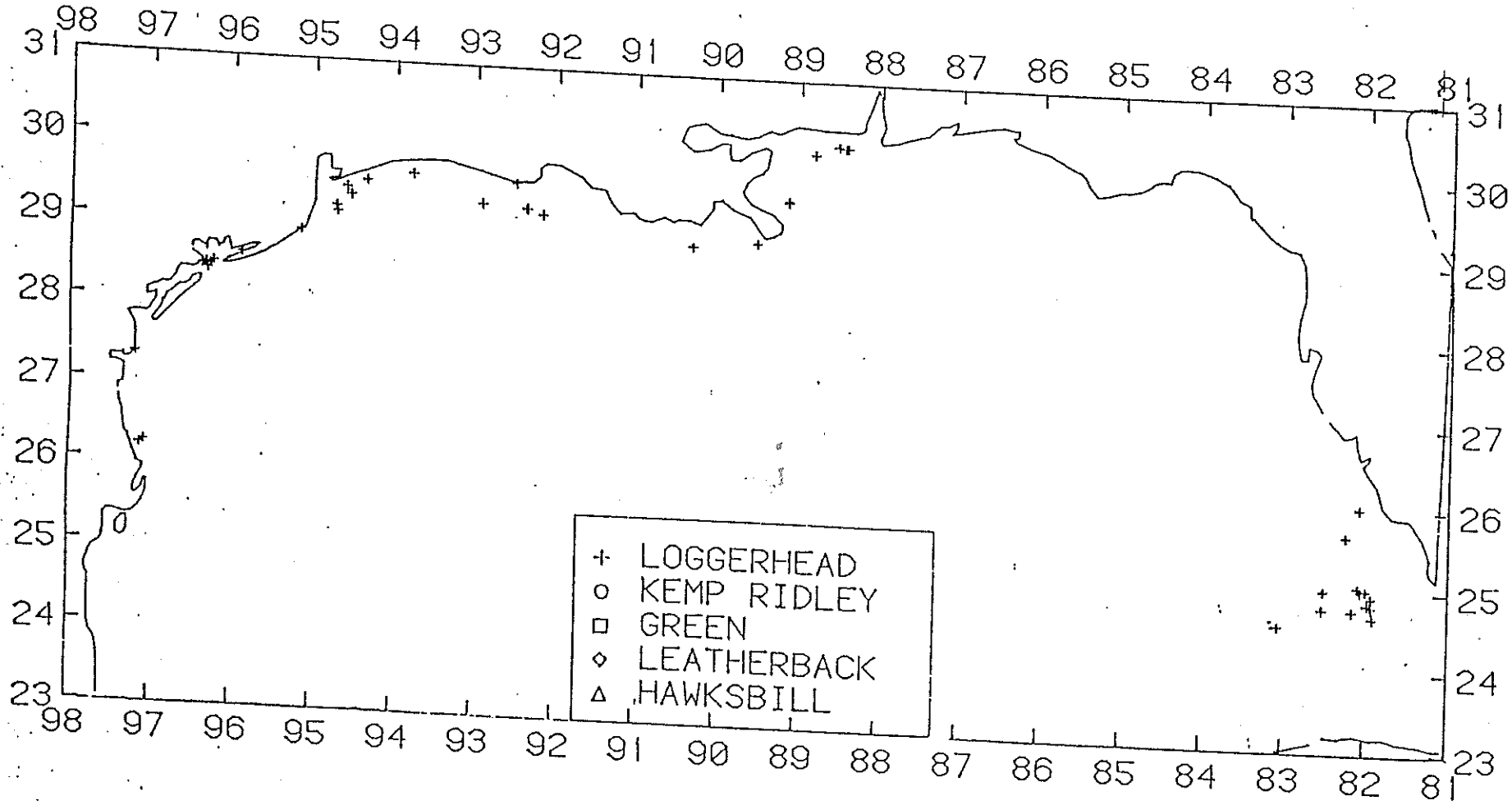

Figure 3. Loggerhead turtle, Caretta caretta, captures in the Gulf of Mexico.

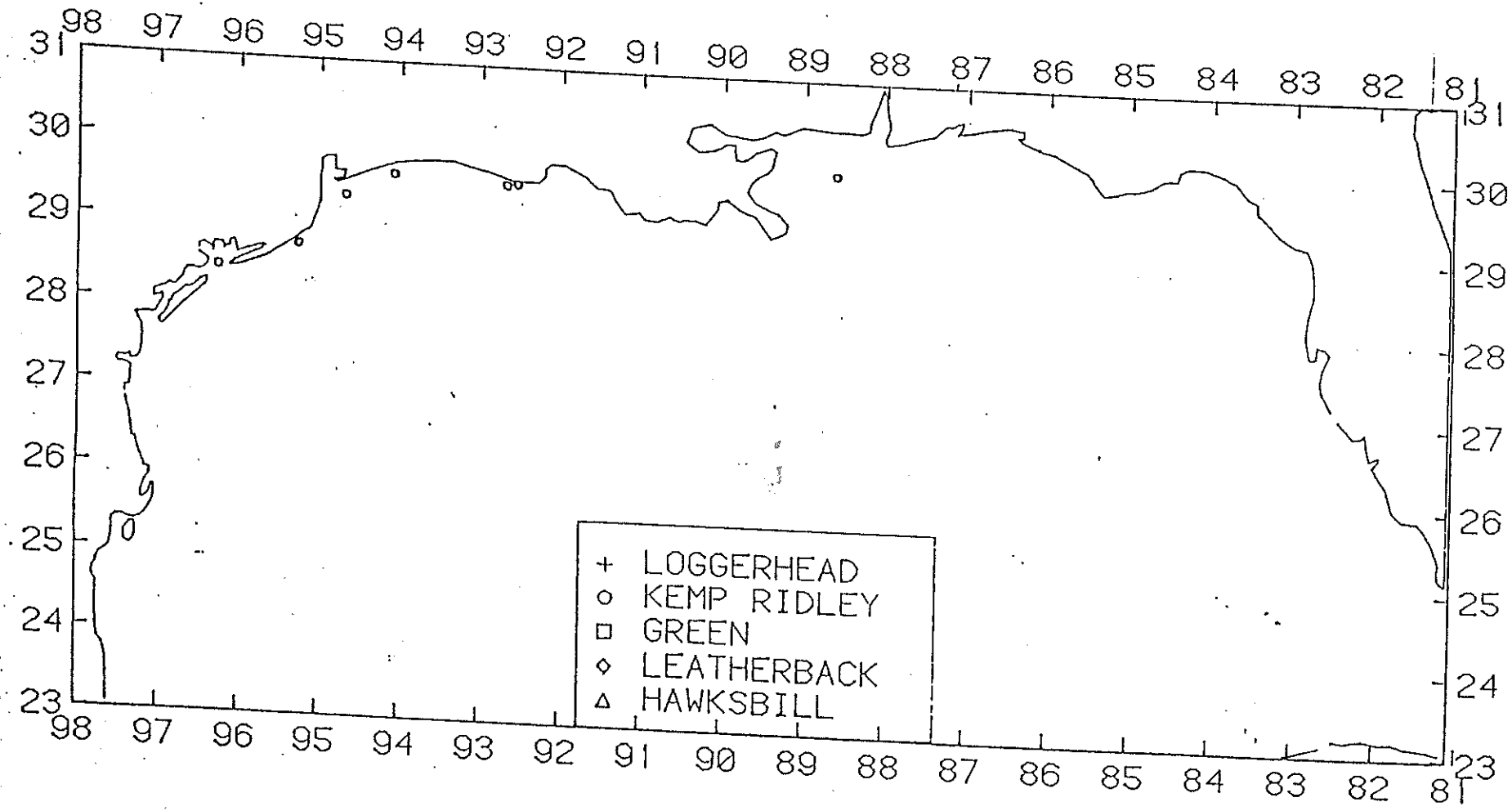

Figure 4. Kemp's ridley turtle, Lepidochelys kempi, captures in the Gulf of Mexico.

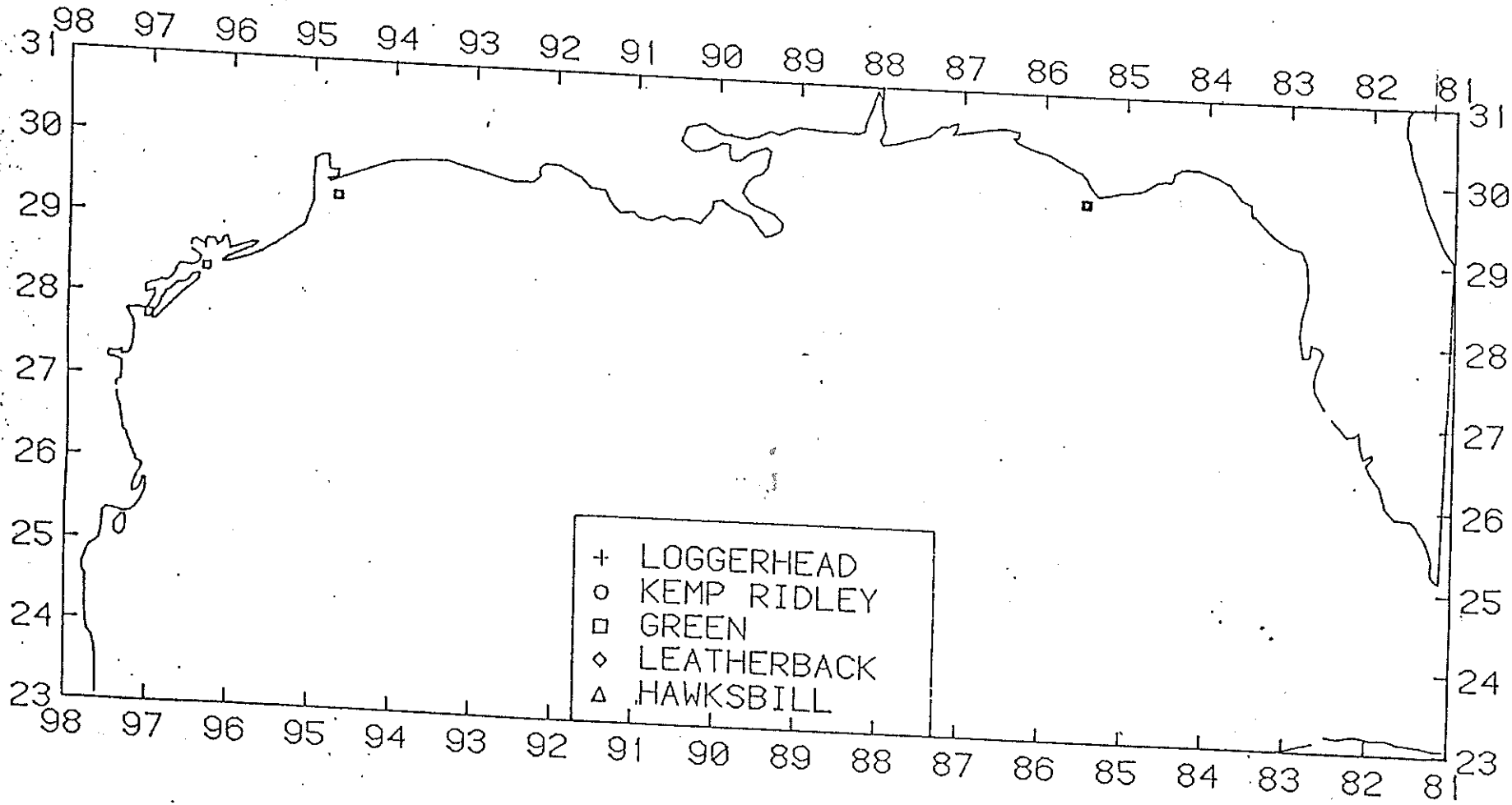

Figure 5. Green turtle, Chelonia mydas, captures in the Gulf of Mexico.

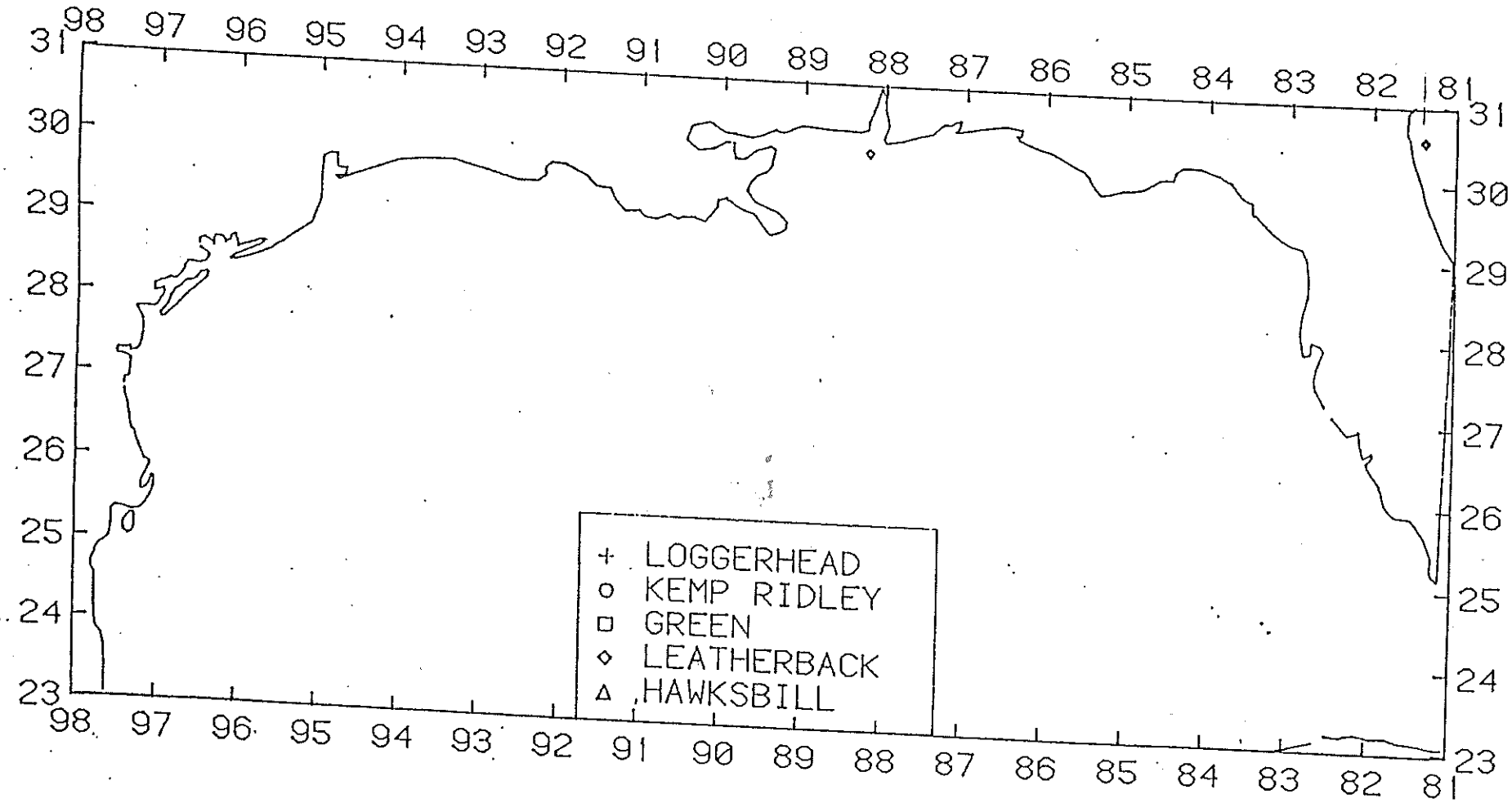

Figure 6. Leatherback turtle, Dermochelys coriacea, captures in the Gulf of Mexico.

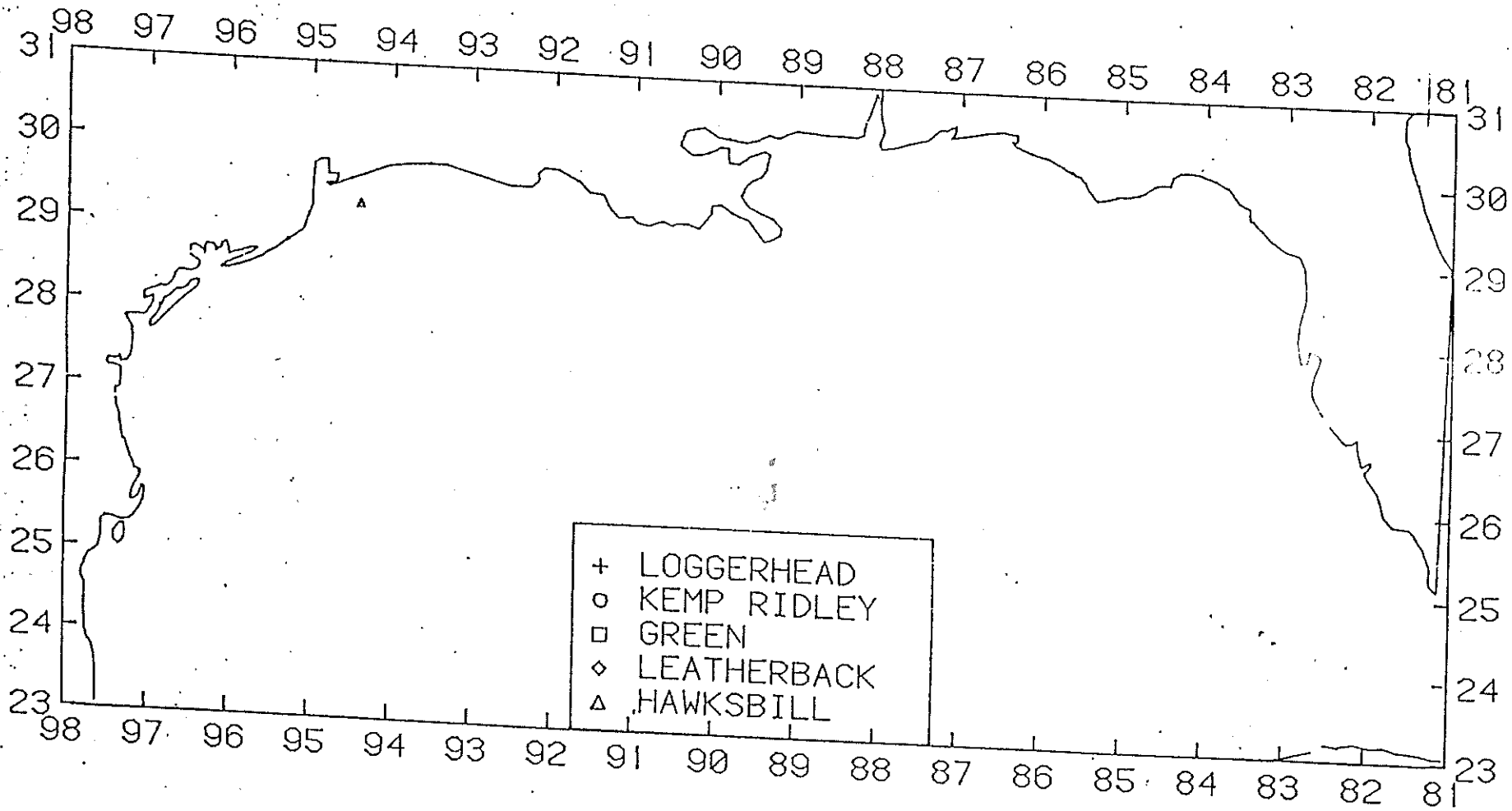

Figure 7. Hawksbill turtle, Eretmochelys imbricata, captures in the Gulf of Mexico.

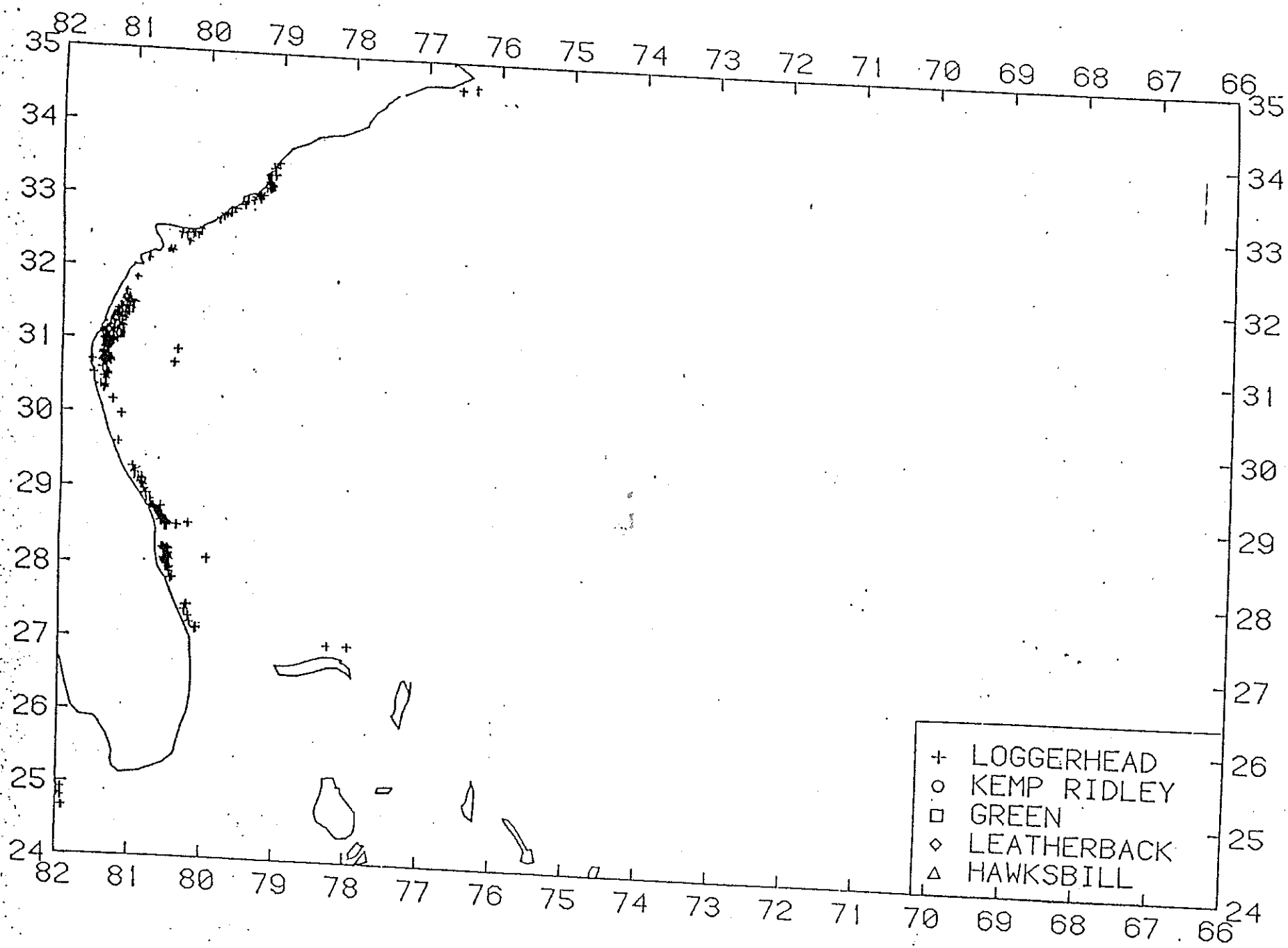

Figure 8. Loggerhead turtle

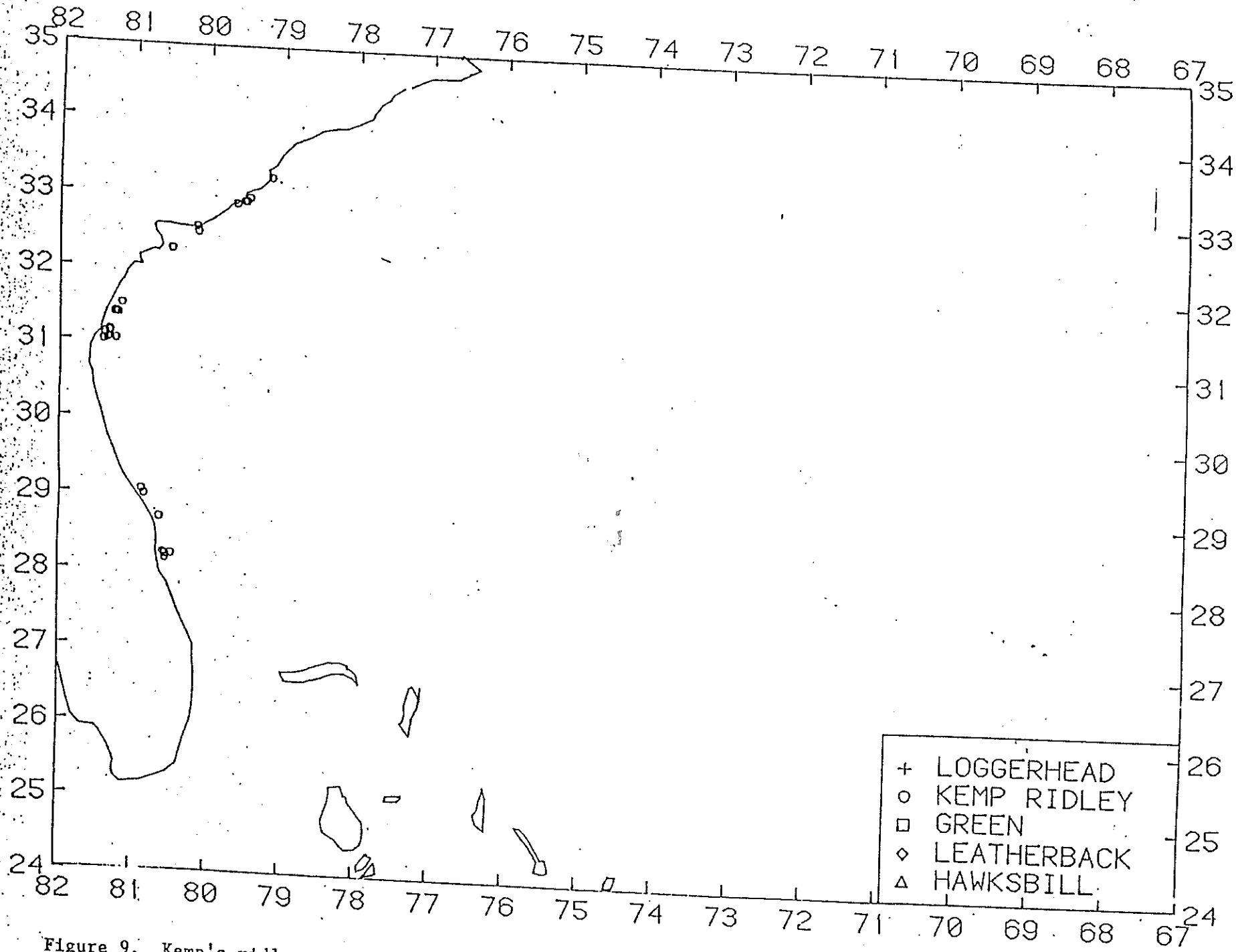

Figure 9. Kemp's ridley turtle, Lepidochelys kempi, captures off

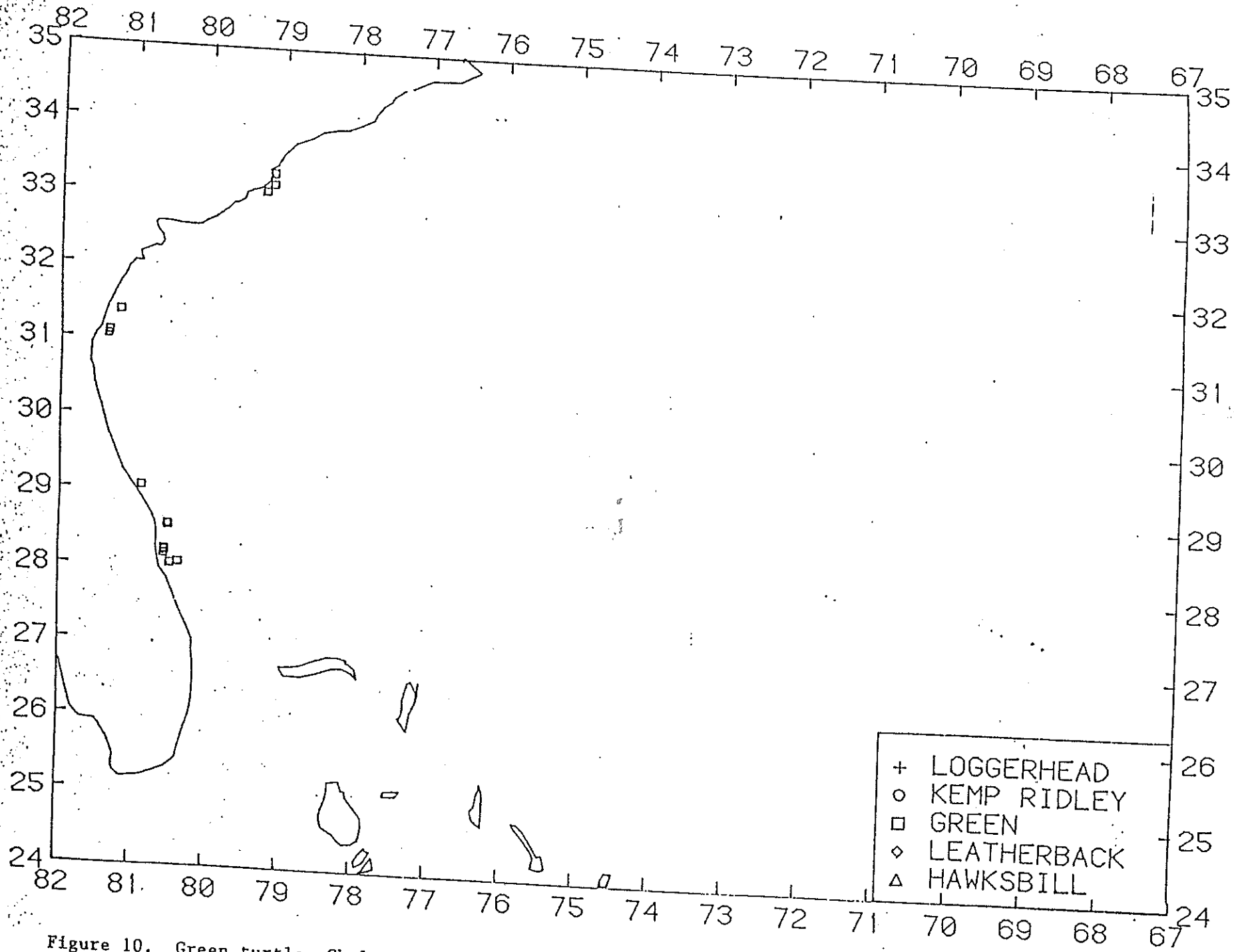

Figure 10. Green turtle, Chelonia myd-

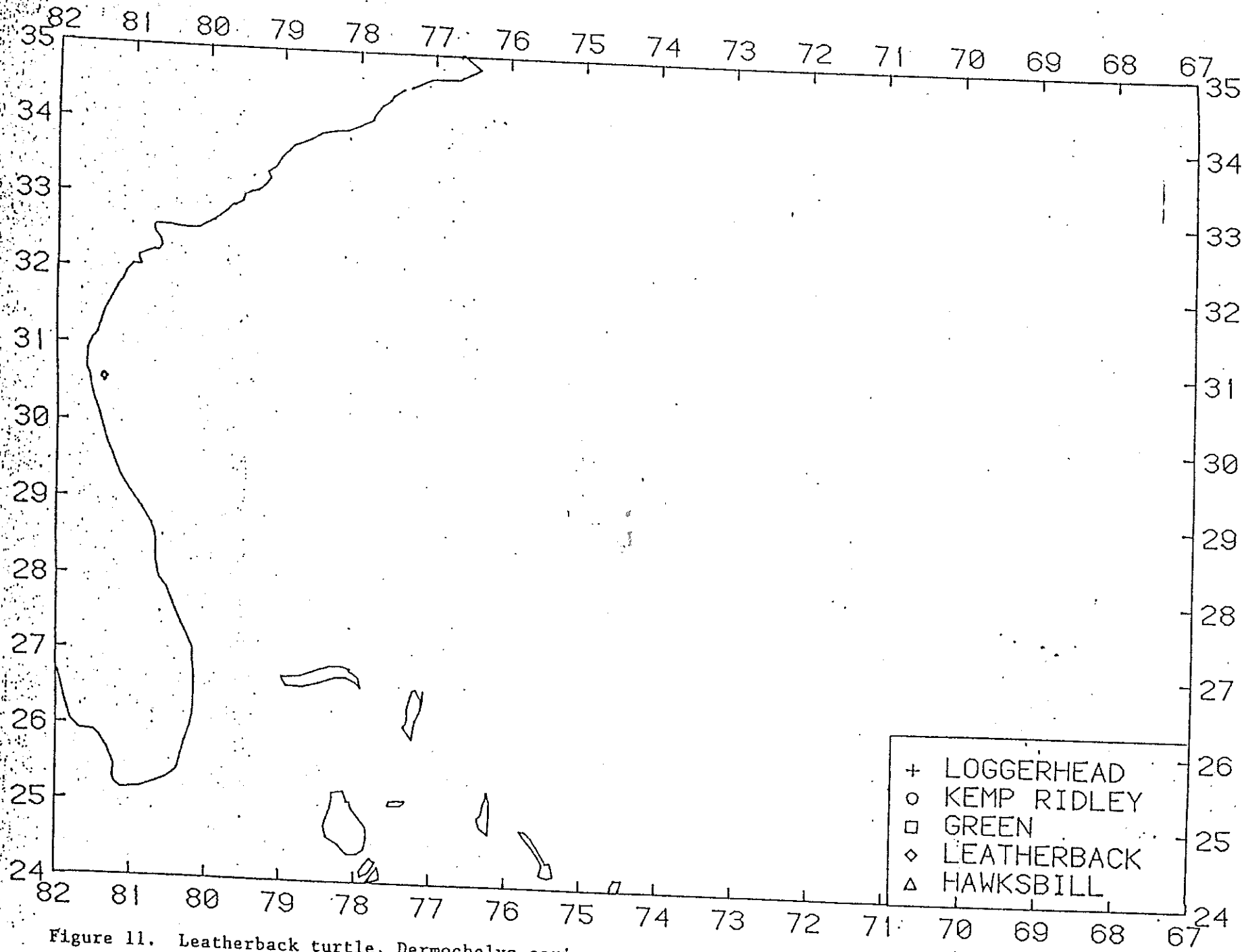

Figure 11. Leatherback turtle, Dermochelys coriacea, captures off the southeastern Atlantic coast.

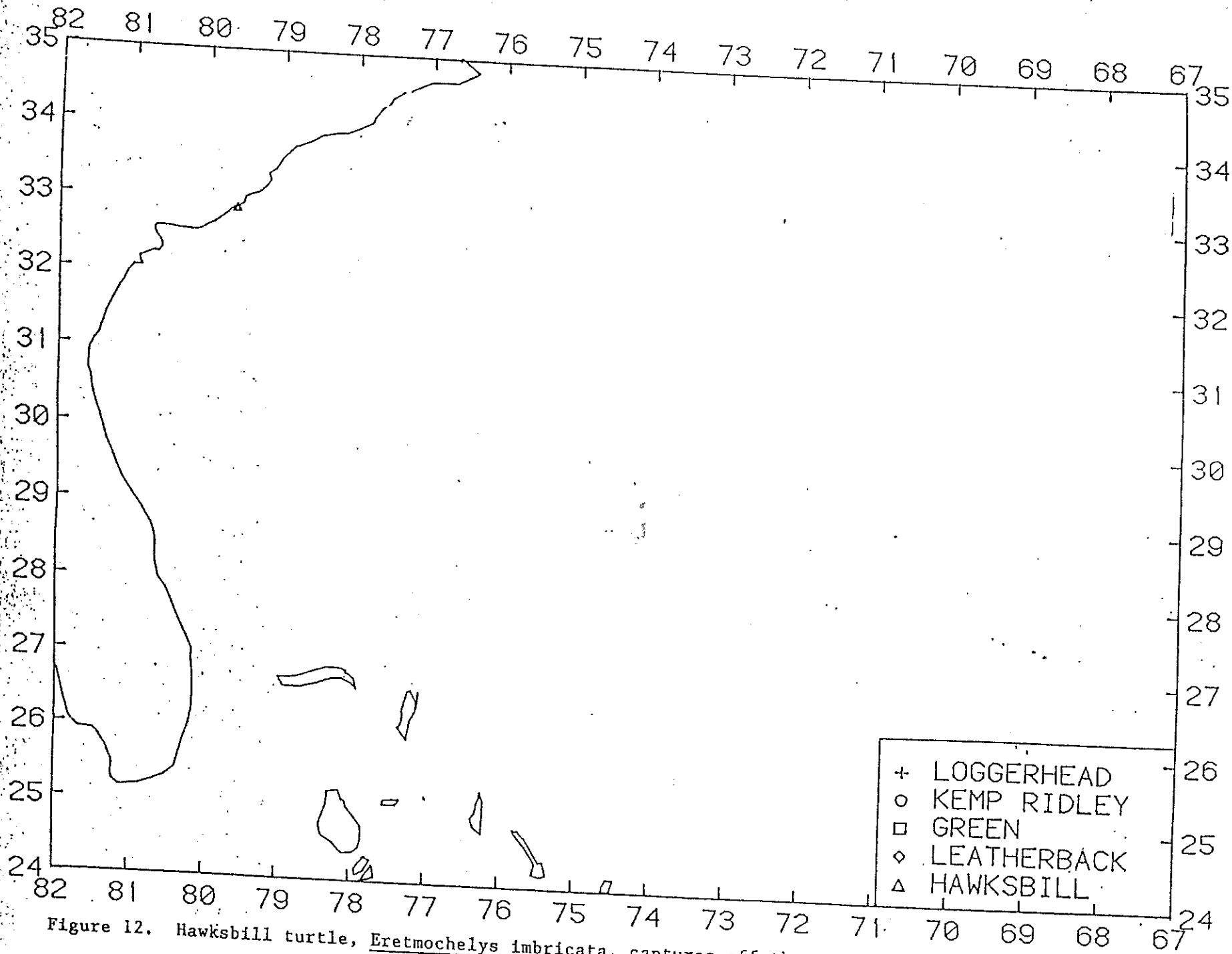

Figure 12. Hawksbill turtle, Eretmochelys imbricata, captures off the southeastern Atlantic

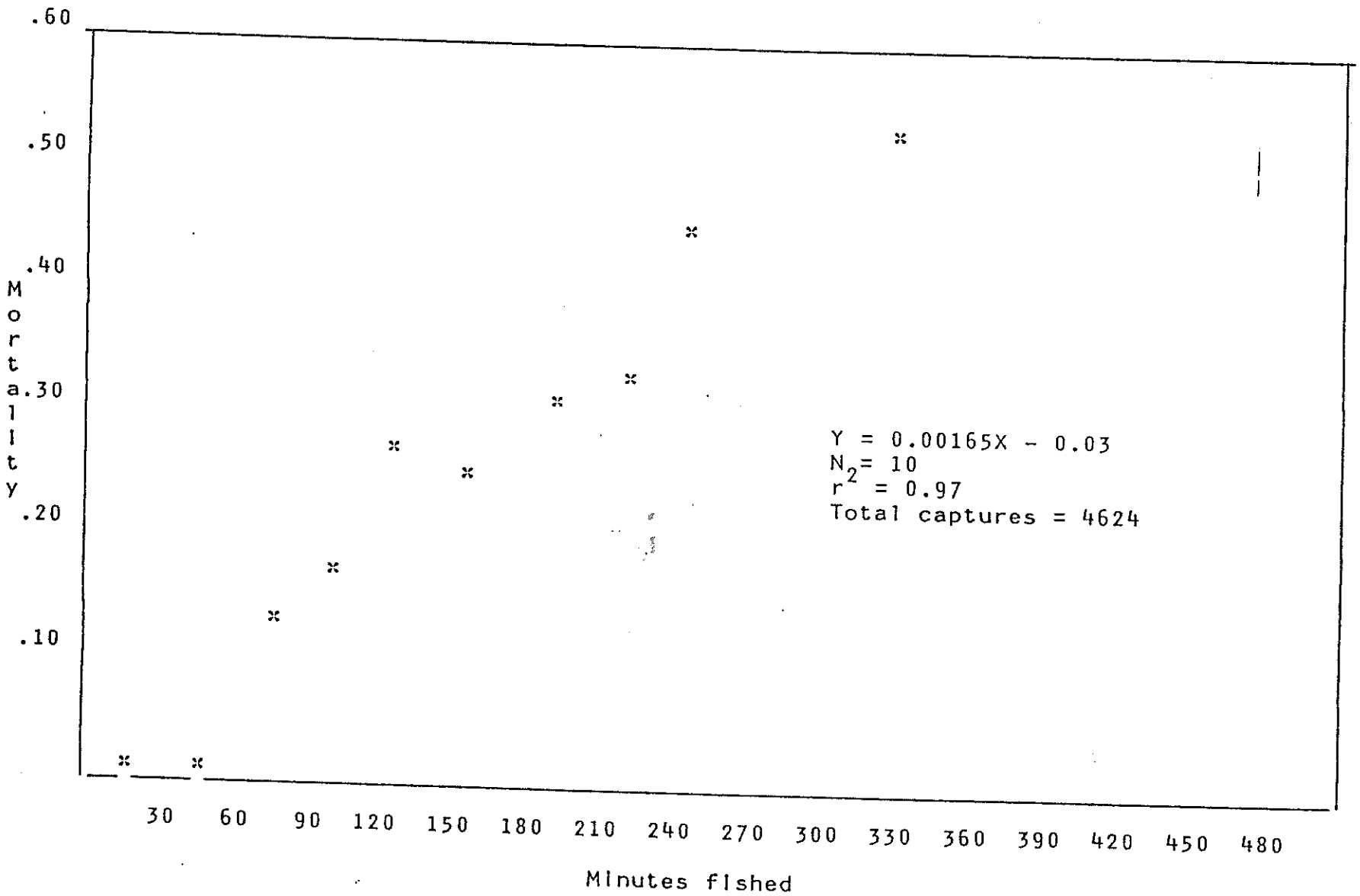

Figure 13. Relationship of length of tow to mortality in sea turtles. Turtles were grouped by 30-minute increments and mean mortality computed. Ten unweighted means were regressed.

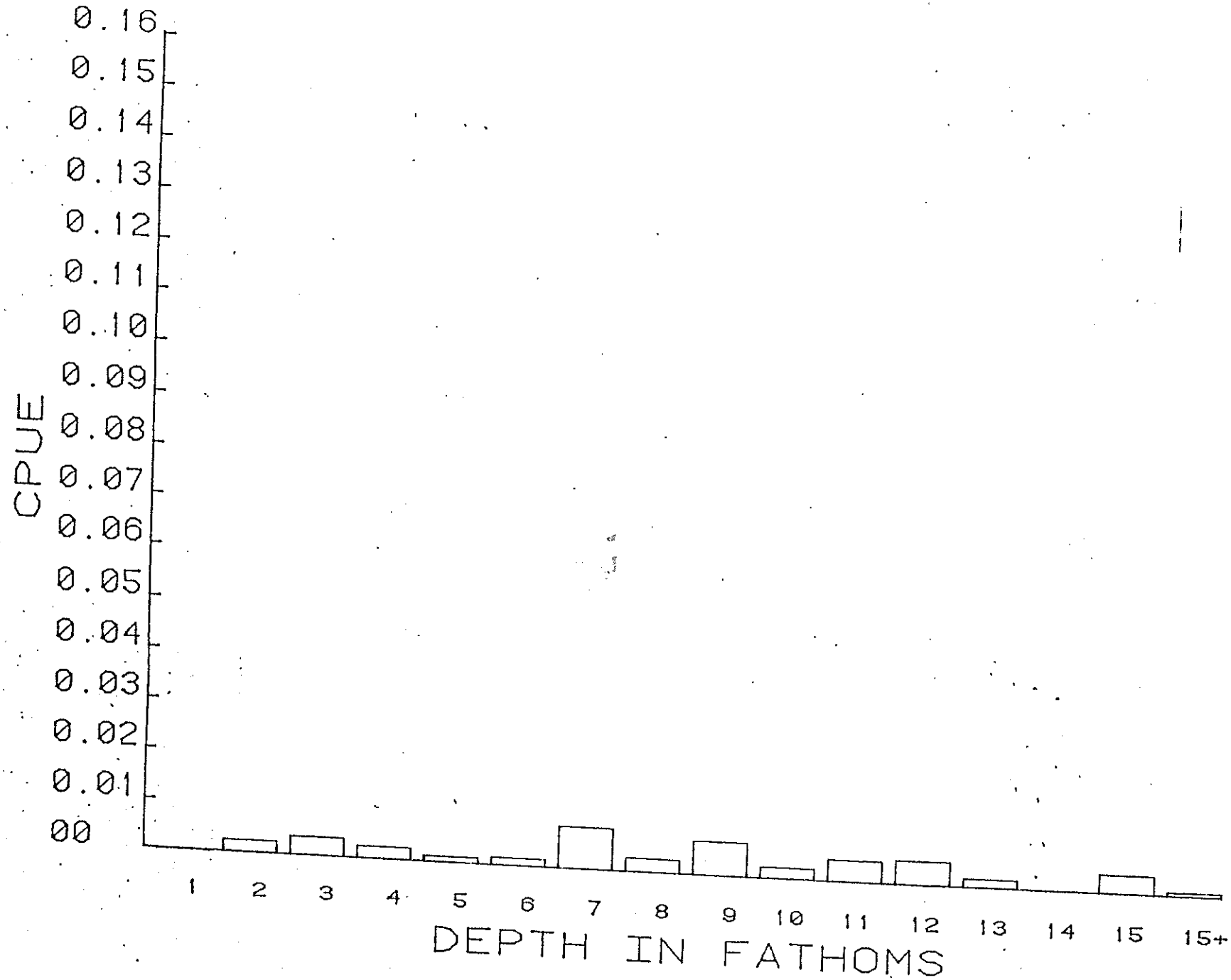

Figure 14. CPUE as a function of depth for all tuna

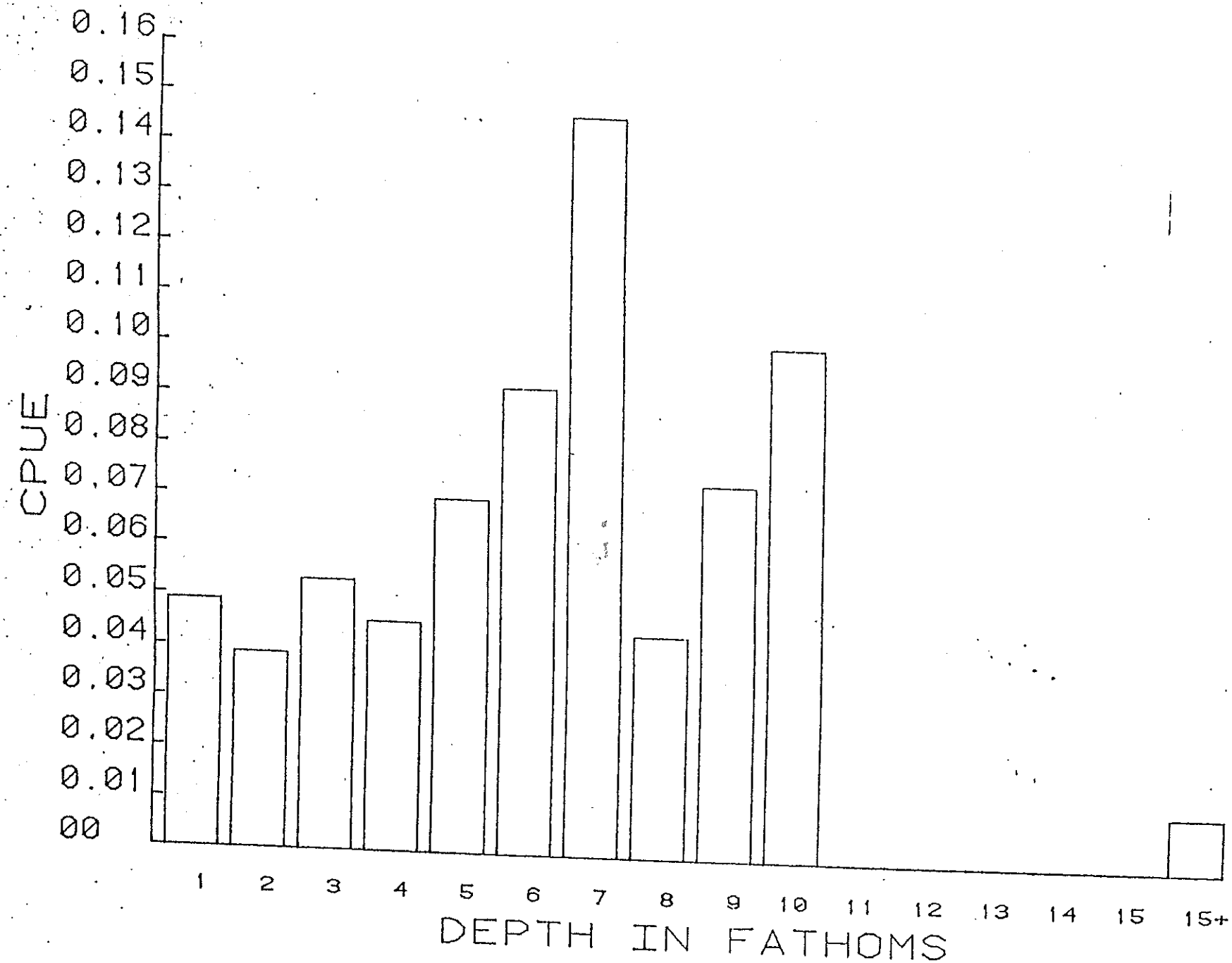

Figure 15. CPUE as a function of depth f

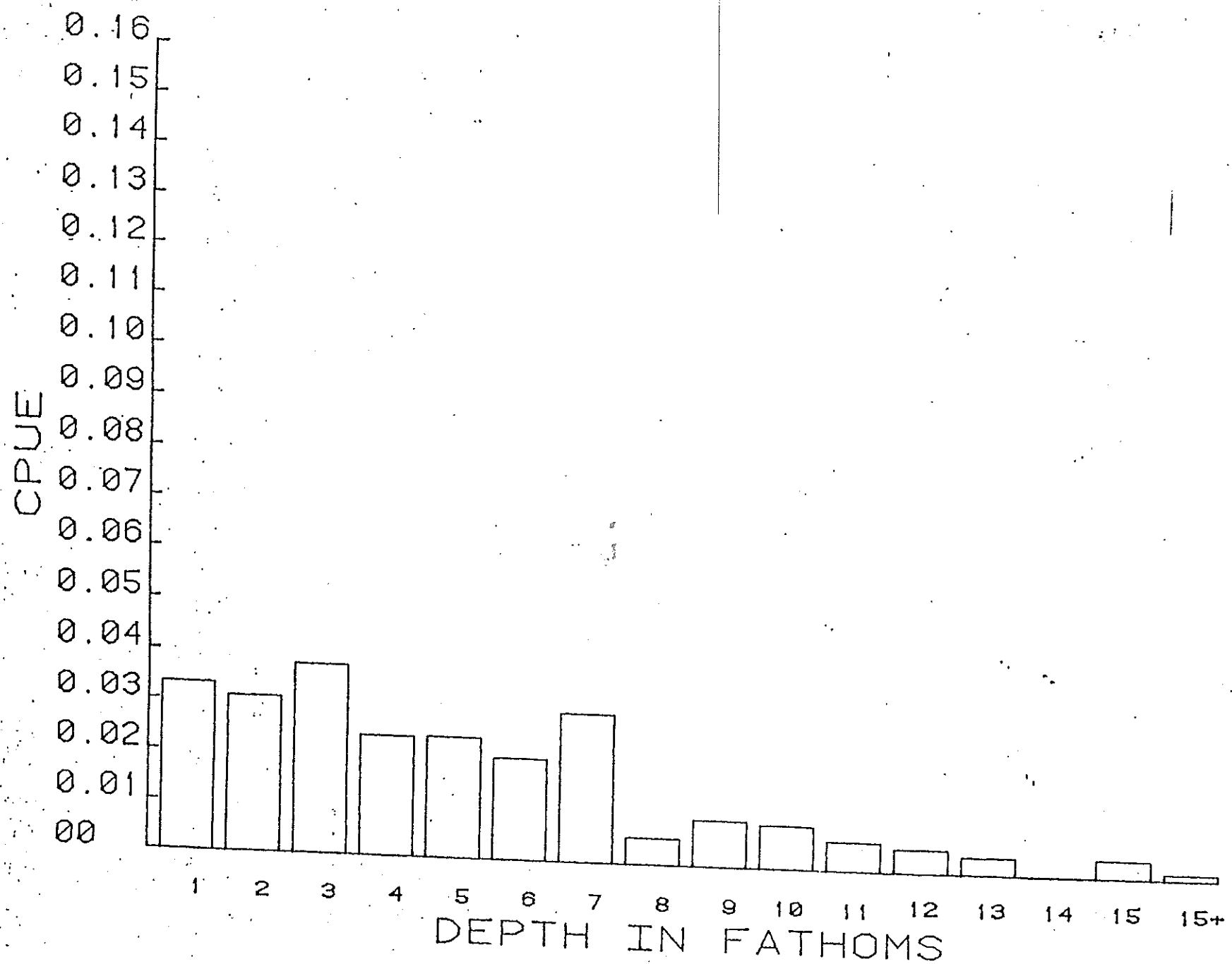

Figure 16. CPUE as a function of depth for all turtle

Table 1. Summary of operating units file for vessels that landed in Texas (1984) by gear type and net size*.

Single rigged vessels with nets larger than 16.8-m headrope length:

778 vessels - mean net size = 18.08
TOTAL EFFORT = 18.08-m net/vessel

Double rigged vessels:

609 vessels - mean net size = 18.56-m
TOTAL EFFORT = 37.12-m net/vessel

Quad rigged vessels:

1237 vessels - mean net size = 11.40-m
TOTAL EFFORT = 45.60-m net/vessel

Average effort (headrope length of nets)

2624 vessels - MEAN EFFORT = 35.47-m net/vessel

* Data provided by National Marine Fisheries Service, Southeast Fisheries Center, Galveston Laboratory.

Table 2. Total fishing effort (standardized to 30.5-m headrope length net hours) in the offshore Gulf of Mexico by statistical zone and season.*

Statistical Zone	Jan.-Mar.	Apr.-Jun.	Jul.-Sept.	Oct.-Dec.	Totals
1	4831	3798	810	1385	10824
2	121731	93255	43584	70033	328604
3	30984	22741	6154	14504	74383
4	17525	22284	6076	12566	58451
5	5501	17988	4261	6099	33849
6	7070	20474	7634	8333	43511
7	7093	38708	7847	8260	61908
8	1865	7590	11946	9835	31236
9	11	229	6	11	257
10	0	1189	3848	357	5394
11	32118	71050	94958	93411	291537
12	916	25154	24612	34871	85553
13	27092	132661	109920	133538	403211
14	26913	87458	76550	70525	261446
15	68727	115404	134030	186504	504665
16	36100	76763	144512	130662	388037
17	47650	99834	145076	127602	420162
18	30348	24808	144568	112349	312073
19	39155	32509	215473	179077	466214
20	20787	26863	121866	81979	251495
21	27913	39362	125446	90167	282888
	379259	960119			4315698

* Data provided by the National Marine Fisheries Service, Southeast Fisheries Center, Galveston Laboratory. Data were standardized by multiplying hours of effort by 35.47/30.5.

SW FLA

LA = 1977521

9.870 818041 1372553 1273580

2170 35.790 3843433

33.970

Table 3. Total NMFS observer sampling effort by statistical zone and season standardized to 30.5-m headrope length net hours.

Statistical Zone	Jan.-Mar.	Apr.-Jun.	Jul.-Sept.	Oct.-Dec.	Totals
1	312	109	9	0	430
2	1,448	4	37	45	1,534
3	312	2	0	46	360
4	75	45	48	12	180
5	4	0	0	2	6
6	0	26	0	16	42
7	0	9	18	10	37
8	21	7	0	6	34
9	0	0	0	0	0
10	18	12	26	19	75
11	67	595	383	53	1,098
12	0	256	112	18	386
13	3	304	303	657	1,267
14	111	132	126	184	553
15	417	27	375	300	1,119
16	154	114	340	400	1,008
17	58	55	336	364	813
18	20	113	1,856	1,754	3,743
19	7	78	1,503	1,468	3,056
20	4	120	286	252	662
21	31	116	66	155	368
22	0	0	1	13	14
23	0	0	0	0	0
24	0	0	0	0	0
25	0	0	0	0	0
26	0	0	0	0	0
27	27	2	0	0	29
28	80	70	5	63	218
29	12	13	5	56	86
30	0	192	429	70	691
31	0	704	3,431	1,746	5,881
32	0	159	857	435	1,451
33	0	51	1,351	185	1,587
Gulf	3,062	2,124	5,825	5,774	16,785
East Coast	119	1,191	6,078	2,555	9,943
Total	3,181	3,315	11,903	8,329	26,728

Table 4. Loggerhead turtle, *Caretta caretta*, captures and mortality by statistical zone and season.

Statistical Zone	Jan.-Mar.	Apr.-Jun.	Jul.-Sept.	Oct.-Dec.	Totals
1	4 (1 dead)	0	0	0	4 (1 dead)
2	4	0	0	0	4
3	2	0	0	1	3
4	1	0	0	0	1
5	0	0	0	0	0
6	0	0	0	0	0
7	0	0	0	0	0
8	0	0	0	0	0
9	0	0	0	0	0
10	0	0	0	0	0
11	0	0	0	0	0
12	0	4 (1 dead)	0	0	4 (1 dead)
13	0	0	2 (1 dead)	0	2 (1 dead)
14	0	0	0	1	1
15	0	0	0	1 (dead)	1 (dead)
16	0	0	1	0	1
17	0	2 (1 dead)	2	0	4 (1 dead)
18	0	0	0	1	1
19	0	0	3	2 (1 dead)	5 (1 dead)
20	0	0	1 (dead)	6 (3 dead)	7 (4 dead)
21	0	0	1	1	2
22	0	0	0	2 (2 dead)	2 (2 dead)
23	0	0	0	0	0
24	0	0	0	0	0
25	0	0	0	0	0
26	0	0	0	0	0
27	0	0	0	0	0
28	21	10	7	6 (1 dead)	44 (1 dead)
29	1	0	1 (dead)	8 (3 dead)	10 (4 dead)
30	0	22 (6 dead)	39 (15 dead)	0	61 (21 dead)
31	0	36 (12 dead)	160 (59 dead)	29 (2 dead)	225 (73 dead)
32	0	23 (8 dead)	31 (13 dead)	9	63 (21 dead)
33	0	2 (1 dead)	72 (15 dead)	13 (2 dead)	87 (18 dead)
Gulf	11 (1 dead)	6 (2 dead)	10 (2 dead)	15 (7 dead)	42 (12 dead)
East Coast	22	93 (27 dead)	310 (103 dead)	65 (8 dead)	490 (138 dead)
Total	33	99 (29 dead)	320 (105 dead)	80 (15 dead)	532 (149 dead)

Table 5. Kemp's ridley turtle, *Lepidochelys kempi*, captures and mortality by statistical zone and season.

Statistical Zone	Jan.-Mar.	Apr.-Jun.	Jul.-Sept.	Oct.-Dec.	Totals
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	0	0
7	0	0	0	0	0
8	0	0	0	0	0
9	0	0	0	0	0
10	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	0	0
13	0	0	0	0	0
14	0	0	0	0	0
15	0	0	0	0	0
16	0	0	0	0	0
17	0	1 (dead)	0	1 (dead)	2 (dead)
18	0	0	0	0	0
19	0	0	1	1	2
20	0	0	0	2	2
21	0	0	0	0	0
22	0	0	0	0	0
23	0	0	0	0	0
24	0	0	0	0	0
25	0	0	0	0	0
26	0	0	0	0	0
27	0	0	0	0	0
28	1	0	0	0	0
29	0	0	1	0	2
30	0	0	0	0	0
31	0	0	0	0	0
32	0	3 (1 dead)	9 (3 dead)	4	13 (3 dead)
33	0	0	1 (dead)	1	5 (2 dead)
			0	0	0
Gulf	0	1 (dead)	1	4 (1 dead)	6 (2 dead)
East Coast	1	3 (1 dead)	11 (4 dead)	5	20 (5 dead)
Total	1	4 (2 dead)	12 (4 dead)	[illegible]	[illegible]

Table 6. Green turtle, *Chelonia mydas*, captures and mortality by statistical zone and season.

Statistical Zone	Jan.-Mar.	Apr.-Jun.	Jul.-Sept.	Oct.-Dec.	Totals
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	0	0
7	0	0	0	0	0
8	0	1	0	0	1 .0029
9	0	0	0	0	0
10	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	0	0
13	0	0	0	0	0
14	0	0	0	0	0
15	0	0	0	0	0
16	0	0	0	0	0
17	0	0	0	0	0
18	0	0	1	0	1 .0[illegible]
19	0	0	0	0	0
20	0	0	0	0	0
21	0	0	0	0	0
22	0	0	0	0	0
23	0	0	0	0	0
24	0	0	0	0	0
25	0	0	0	0	0
26	0	0	0	0	0
27	0	0	0	0	0
28	2	1	0	0	3 .0[illegible]
29	0	0	0	0	0
30	0	0	0	0	0
31	0	1 (1 dead)	1 (1 dead)	1	3 (2 dead) .00[illegible]
32	0	0	0	0	0
33	0	0	3	0	3 .0[illegible]
Gulf	0	1	1	0	2
East Coast	2	2 (1 dead)	4 (1 dead)	1	9 (2 dead)
Total	2	3 (1 dead)	5 (1 dead)	1	11 (2 dead)

Table 7. Leatherback turtle, *Dermochelys coriacea*, captures and mortality by statistical zone and season.

Statistical Zone	Jan.-Mar.	Apr.-Jun.	Jul.-Sept.	Oct.-Dec.	Totals
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	0	0
7	0	0	0	0	0
8	0	0	0	0	0
9	0	0	0	0	0
10	0	0	0	0	0
11	0	0	0	0	0
12	0	1 (dead)	0	0	1 (dead)
13	0	0	0	0	0
14	0	0	0	0	0
15	0	0	0	0	0
16	0	0	0	0	0
17	0	0	0	0	0
18	0	0	0	0	0
19	0	0	0	0	0
20	0	0	0	0	0
21	0	0	0	0	0
22	0	0	0	0	0
23	0	0	0	0	0
24	0	0	0	0	0
25	0	0	0	0	0
26	0	0	0	0	0
27	0	0	0	0	0
28	0	0	0	0	0
29	0	0	0	0	0
30	0	0	0	0	0
31	0	3 (1 dead)	0	0	3 (1 dead)
32	0	0	0	0	0
33	0	0	0	0	0
Gulf	0	1 (dead)	0	0	1 (dead)
East Coast	0	3 (1 dead)	0	0	3 (1 dead)
Total	0	4 (2 dead)	0	0	

Table 8. Hawksbill turtle, *Eretmochelys imbricata*, captures and mortality by statistical zone and season.

Statistical Zone	Jan.-Mar.	Apr.-Jun.	Jul.-Sept.	Oct.-Dec.	Totals
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	0	0
7	0	0	0	0	0
8	0	0	0	0	0
9	0	0	0	0	0
10	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	0	0
13	0	0	0	0	0
14	0	0	0	0	0
15	0	0	0	0	0
16	0	0	0	0	0
17	0	0	0	0	0
18	0	0	0	0	0
19	0	0	1	0	1
20	0	0	0	0	0
21	0	0	0	0	0
22	0	0	0	0	0
23	0	0	0	0	0
24	0	0	0	0	0
25	0	0	0	0	0
26	0	0	0	0	0
27	0	0	0	0	0
28	0	0	0	0	0
29	0	0	0	0	0
30	0	0	0	0	0
31	0	0	0	0	0
32	0	0	0	0	0
33	0	0	0	1	1
			0	0	0
Gulf	0	0	1	0	1
East Coast	0	0	0	1	1
Total	0	0	1	1	2

Table 9. Mean depth (m) and tow time (mins.) for all tows (N) by statistical zone.

		Depth (meters)			Mins. fished (mins)		
Stat. zone	N	Mean	Std. error of mean	Range	Mean	Std. error of mean	Range
1	139	15.5	0.46	2-64	203.8	6.26	90.0-385.0
2	569	26.6	0.24	18-46	263.1	4.52	10.0-745.0
3	133	24.0	0.64	15-53	209.3	8.76	30.0-430.0
4	97	12.5	0.36	2-22	137.9	8.16	30.0-360.0
5	16	7.1	0.60	2-11	50.0	6.16	35.0-135.0
6	17	8.2	2.86	2-51	157.5	9.64	28.0-200.0
7	35	6.3	0.36	4-11	144.9	9.24	30.0-225.0
8	22	7.9	0.53	4-11	130.6	19.45	10.0-350.0
9	0	0	0	0	0	0	0
10	54	8.1	0.43	2-15	174.7	9.11	10.0-300.0
11	564	20.4	0.77	4-84	119.0	4.79	8.0-605.0
12	157	7.5	0.29	2-15	136.7	6.01	10.0-355.0
13	524	23.3	0.88	2-91	125.2	4.34	10.0-567.0
14	326	18.7	1.20	2-99	102.3	5.70	10.0-502.0
15	487	22.1	0.91	2-90	151.4	5.81	10.0-600.0
16	245	13.4	0.82	2-119	246.6	8.25	10.0-750.0
17	230	12.0	0.56	4-64	239.6	9.31	10.0-535.0
18	1471	10.2	0.14	2-42	223.2	2.62	10.0-720.0
19	610	16.8	0.36	2-62	238.1	5.07	10.0-840.0
20	205	25.8	0.85	4-77	259.9	12.62	10.0-815.0
21	89	27.7	1.12	7-73	269.4	23.16	10.0-840.0
22	4	25.6	5.33	16-37	210.0	104.64	30.0-420.0
23	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0
27	7	31.9	5.19	11-42	160.0	10.12	120.0-185.0
28	59	17.8	1.38	7-46	143.4	8.15	25.0-305.0
29	25	14.0	.60	7-18	136.6	11.43	50.0-240.0
30	415	8.0	.15	4-16	146.0	3.29	15.0-370.0
31	3827	5.0	.04	2-49	144.6	0.85	10.0-567.0
32	694	5.7	.06	2-11	143.9	1.49	10.0-250.0
33	490	5.9	.10	2-13	147.4	1.88	25.0-330.0

Table 10. Mean depth of capture and minutes fished for loggerhead turtles (N) by statistical zone. Asterisk (*) indicates that the 95% confidence limits do not overlap with those of effort data.

		Depth (meters)			Mins. fished (mins.)		
	N	Mean	St. error of mean	Range	Mean	St. error of mean	Range
1	4	16.9	2.29	11-22	156.3	21.83	105.0-195.0
2	4	29.7	3.77	20-37	352.5*	54.52	190.0-420.0
3	3	21.3*	0.60	20-22	195.0	31.23	150.0-255.0
4	1	15.0*	0.00	15-15	150.0	0.00	150.0-150.0
5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0
11	4	12.3*	0.46	11-13	272.5	114.70	115.0-605.0
12	2	12.8*	0.00	13-13	92.5*	2.50	90.0-95.0
13	1	27.4*	0.00	27-27	153.0*	0.00	153.0-153.0
14	1	12.8*	0.00	13-13	240.0*	0.00	240.0-240.0
15	0	0	0	0	0	0	0
16	4	11.0	3.88	4-20	195.0	19.47	150.0-245.0
17	1	5.5*	0.00	5-5	350.0*	0.00	350.0-350.0
18	5	11.7	1.98	5-16	271.2	48.56	145.0-385.0
19	7	10.2*	1.48	5-16	253.6	49.20	70.0-390.0
20	1	18.3*	0.00	18-18	315.0*	0.00	315.0-315.0
21	2	20.1	3.66	16-24	327.5	22.50	305.0-350.0
22	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0
27	11	11.6*	0.82	7-15	21.6*	3.63	12.0-48.0
28	47	14.3	1.55	5-79	97.0*	9.05	10.0-200.0
29	20	13.4	0.46	9-18	108.4	18.88	12.0-230.0
30	74	8.1	0.38	4-13	153.1	7.09	14.0-280.0
31	250	5.5*	0.15	2-11	164.7*	3.41	35.0-325.0
32	63	5.7	0.18	4-11	146.9	4.28	60.0-240.0
33	94	5.9	0.22	2-11	152.5	4.10	40.0-245.0

Table 11. Mean depth of capture and minutes fished for Kemp's ridley turtles (N) by statistical zone. Asterisk (*) indicates that the means and 95% confidence limits do not overlap with those of effort data.

	Depth (meters)				Mins. fished (mins.)		
	N	Mean	St. error of mean	Range	Mean	St. error of mean	Range
1	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0
16	2	5.5*	1.83	4-7	200.0	20.0	180.0-220.0
17	0	0	0	0	0	0	0
18	2	9.1	2.74	7-13	275.0	65.0	210.0-340.0
19	2	6.4*	0.91	5-7	225.0	105.0	120.0-330.0
20	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0
28	2	11.9	2.74	9-15	100.0	85.0	15.0-185.0
29	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0
31	14	5.0	0.55	2-9	117.8*	11.5	60.0-225.0
32	5	6.2	0.93	4-9	152.3	8.2	120.0-180.0
33	0	0	0	0	0	0	0

Table 12. Mean depth of capture and minutes fished for green turtles (N) by statistical zone. Asterisk (*) indicates that the 95% confidence limits do not overlap with effort data.

	Depth (meters)				Mins. fished (mins.)		
	N	Mean	St. error of mean	Range	Mean	St. error of mean	Range
1	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0
8	1	5.5*	0.00	5-5	165.0	0.00	165.0-165.0
9	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0
18	1	12.8*	0.00	13-13	90.0*	0.00	90.0-90.0
19	1	7.3*	0.00	7-7	180.0*	0.00	180.0-180.0
20	1	14.6*	0.00	15-15	360.0*	0.00	360.0-360.0
21	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0
24	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0
28	3	9.1*	1.06	7-11	110.7	52.9	22.0-205.0
29	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0
31	3	7.3*	1.06	5-9	172.0	25.44	130.0-218.0
32	0	0	0	0	0	0	0
33	3	7.9	1.61	5-11	161.7	42.85	80.0-225.0

Table 13. Observer effort, CPUE, shrimping effort, estimated captures and estimated mortality of loggerhead turtles by areas.

Area 1/	Observer Effort 2/	CPUE + 95% c.i. on CPUE	Shrimping Effort	Estimated Captures 4/	Estimated Mortality 5/
Atlantic	9,943	0.0456 ±0.0039	704,376 6/	32,120±2747	6,745±577
Gulf					
Eastern	2,589	0.0046 ±0.0026	611,530 3/	2,813±1590	956±541
Central	6,353	0.0022 ±0.0012	2,391,498 3/	5,261±2870	1,157±631
Western	7,829	0.0020 ±0.0010	1,312,670 3/	2,625±1313	998±499
Overall	16,771	0.0025 ±0.0008	4,315,698 3/	10,789±3453	3,129±1001

1. Atlantic area includes shrimp statistical zones 24-33.
Eastern area includes shrimp statistical zones 1-7.
Central area includes shrimp statistical zones 8-17.
Western area includes shrimp statistical zones 18-21.

2. Based on NMFS observer data standardized to 30.5-m trawl hours.

3. Using shrimp fishing effort for the offshore Gulf of Mexico standardized to 30.5-m headrope length net hours, Table 2.

4. Captures = (CPUE x shrimping effort) ± (95% c.i. on CPUE x shrimping effort).

5. Based on the mean minutes fished/tow in the area. See Figure 13.
Mortality = (mortality rate x captures)
± (mortality rate x (95% c.i. of captures)).

6. Atlantic offshore shrimp trawling effort standardized to hours of 30.5-m headrope length trawls.

Table 14. Observer effort, CPUE, shrimping effort, estimated captures and estimated mortality of Kemp's ridley turtles by areas.

Area 1/	Observer Effort 2/	CPUE + 95% c.i. on CPUE	Shrimping Effort	Estimated Captures 4/	Estimated Mortality 5/
Atlantic	9,943	0.0018 ±0.0008	704,376 7/	1268±564	266±119
Gulf					
Eastern	2,589	0	611,530 3/	245±245 6/	83±83
Central	6,353	0.0003 ±0.0004	2,391,498 3/	717±957	158±210
Western	7,829	0.0005 ±0.0005	1,312,670 3/	656±656	249±249
Overall	16,785	0.0004 ±0.0004	4,315,698 3/	1726±1726	501±501

1. Atlantic area includes shrimp statistical zones 24-33.
   Eastern area includes shrimp statistical zones 1-7.
   Central area includes shrimp statistical zones 8-17.
   Western area includes shrimp statistical zones 18-21.

2. Based on NMFS observer data standardized to 30.5-m trawl hours.

3. Using shrimp fishing effort for the offshore Gulf of Mexico standardized to 30.5-m headrope length net hours, Table 2.

4. Captures = (CPUE x shrimping effort) ± 95% c.i. on CPUE x shrimping effort).

5. Based on the mean minutes fished/tow for the area. See Figure 13.
   Mortality = (mortality rate x captures)
   ± (mortality rate x (95% c.i. of captures)).

6. Based on the Gulf CPUE.

7. Atlantic offshore shrimp trawling effort standardized to hours of 30.5-m headrope length trawls.

Table 15. Observer effort, CPUE, shrimping effort, estimated captures and estimated mortality of green turtles.

Area 1/	Observer Effort 2/	CPUE + 95% c.i. on CPUE	Shrimping Effort	Estimated Captures 4/	Estimated Mortality 5/
Atlantic	9,943	0.0007 ±0.0003	704,376 7/	493±211	104±44
Gulf					
Eastern	2,589	0	611,530 3/	61±122 6/	21±41
Central	6,353	0.0003 ±0.0003	2,391,498 3/	717±717 ?	158±158 ?
Western	7,843	0	1,312,670 3/	131±262 6/	50±100
Overall	16,785	0.0001 ±0.0002	4,315,698 3/	432±863	125±250

1. Atlantic area includes shrimp statistical zones 24-33.
   Eastern area includes shrimp statistical zones 1-7.
   Central area includes shrimp statistical zones 8-17.
   Western area includes shrimp statistical zones 18-21.

2. Based on NMFS observer data and standardized to 30.5-m trawl hours.

3. Using shrimp fishing effort for the offshore Gulf of Mexico standardized to 30.5-m headrope length net hours, Table 2.

4. Captures = (CPUE x shrimping effort) ± 95% c.i. on CPUE x shrimping effort.

5. Based on the mean minutes fished/tow for the area. See Figure 13.
   Mortality = (mortality rate x captures)
   ± (mortality rate x (95% c.i. of captures)).

6. Based on the CPUE for the Gulf.

7. Atlantic offshore shrimp trawling effort standardized to hours of 30.5-m headrope length trawls.

Table 16. Observer effort, CPUE, shrimping effort, estimated captures and estimated mortality of hawksbill turtles.

Area 1/	Observer Effort 2/	CPUE +95% c.i. on CPUE	Shrimping Effort	Estimated Captures 4/	Estimated Mortality 5/
Atlantic	9,943	0.0001 ±0.0002	704,376 7/	70±141	15±30
Gulf					
Eastern	2,589	0	611,530 3/	61±122 6/	21±41
Central	6,353	0	2,391,498 3/	239±478 6/	53±105
Western	7,843	0.0001 ±0.0002	1,312,670 3/	131±262	50±100
Overall	16,785	0.0001 ±0.0002	4,315,698 3/	432±863	125±250

1. Atlantic area includes shrimp statistical zones 24-33.
   Eastern area includes shrimp statistical zones 1-7.
   Central area includes shrimp statistical zones 8-17.
   Western area includes shrimp statistical zones 18-21.

2. Based on NMFS observer data and standardized to 30.5-m trawl hours.

3. Using shrimp fishing effort for the offshore Gulf of Mexico standardized to 30.5-m headrope length net hours, Table 2.

4. Captures = (CPUE x shrimping effort) ± 95% c.i. on CPUE x shrimping effort).

5. Based on the mean minutes fished/tow in the area. See Figure 13.
   Mortality = (mortality rate x captures)
   ± (mortality rate x (95% c.i. of captures)).

6. Based on the CPUE for the Gulf.

7. Atlantic offshore shrimp trawling effort standardized to hours of 30.5-m headrope length trawls.

Table 17. Observer effort, CPUE, shrimping effort, estimated captures and estimated mortality of leatherback turtles.

Area 1/	Observer Effort 2/	CPUE +95% c.i. on CPUE	Shrimping Effort	Estimated Captures 4/	Estimated Mortality 5/
Atlantic	9,943	0.0003 ±0.0004	704,376 7/	211±282	44±59
Gulf					
Eastern	2,589	0	611,530 3/	61±122 6/	21±41
Central	6,353	0.0002 ±0.0004	2,391,498 3/	478±957	105±210
Western	7,829	0	1,312,670 3/	131±262 6/	50±100
Overall	16,785	0.0001 ±0.0002	4,315,698 3/	432±863	125±250

1. Atlantic area includes shrimp statistical zones 24-33.
   Eastern area includes shrimp statistical zones 1-7.
   Central area includes shrimp statistical zones 8-17.
   Western area includes shrimp statistical zones 18-21.

2. Based on NMFS observer data and standardized to 30.5-m trawl hours.

3. Using shrimp fishing effort for the offshore Gulf of Mexico standardized to 30.5-m headrope length net hours, Table 2.

4. Captures = (CPUE x shrimping effort) ± 95% c.i. on CPUE x shrimping effort.

5. Based on the mean minutes fished/tow in the area. See Figure 13.
   Mortality = (mortality rate x captures)
   ± (mortality rate x (95% c.i. of captures)).

6. Based on the CPUE for the Gulf.

7. Atlantic offshore shrimp trawling effort standardized to hours of 30.5-m headrope length trawls.