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Tow Times of Shrimp Trawlers in the Gulf of Mexico (Louisiana and Texas) and Atlantic (North Carolina) Inshore Waters 1987 - 1988

BY

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ABSTRACT

An examination of shrimping practices in both the Gulf of Mexico and South Atlantic inshore waters suggests that major changes will be required for fisherman in the Gulf of Mexico to conform to practices required by TED regulations. Two-thirds to three-fourths of all tows by Gulf of Mexico inshore shrimpers are now longer than the 90 minute trawl limit, with tow time increasing from early summer through the fall. Vessel length varied with location, with vessels below 25 ft operating primarily in inshore waters of Louisiana.

The limited data suggest, however, that only minor modifications may be required in the South Atlantic, where approximately 80% of all tows were within the 90 minute limit. Close supervision may be required to ensure that shrimpers adhere to regulations.

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INTRODUCTION

The Endangered Species Act of 1973 requires agencies of the federal government to actively protect those species which are declared endangered or threatened. Several marine turtles including the Kemp's ridley (endangered), hawksbill and leatherback (endangered), green (endangered in Florida and threatened elsewhere), and the loggerhead (threatened) have been so designated. The National Marine Fisheries Service (NMFS) has been charged with the responsibility to protect and manage these turtles in U. S. marine waters through a memorandum of understanding with the U. S. Fish and Wildlife Service.

Mortality of marine turtles in offshore waters of the Gulf of Mexico and South Atlantic oceans due to commercial shrimpers has been estimated at 5,000-50,000 for loggerhead turtles and 500 to 5,000 for Kemps' ridley (Magnuson 1990; see also Henwood and Stuntz 1987, Thompson 1988). Inshore mortality data are limited, but preliminary numbers from the sea turtle stranding and salvage network of NMFS in Miami (Marcel Duronsolet, personal communication) show 20 marine turtles stranded in Louisiana inshore waters and 296 in Texas inshore waters since June 1980.

NMFS has promulgated regulations which would protect the species in U. S. waters, both offshore and inshore. In addition

to the use of turtle excluder devices (TEDs) offshore, NMFS ruled that, effective May 1, 1990, trawling within inshore waters must 1) be limited to 90 minute tows for vessels less than 25 ft, or 2) that a TED must be present in each shrimp net.

During the two years prior to the implementation of the regulations, the Galveston Laboratory of the NMFS conducted special surveys of the inshore commercial shrimp fishery to obtain base-line information on fishing practices in several Louisiana and Texas bay systems. Although many data items were collected, mean time per tow, the frequency of tows less than 90 minutes and vessel length were of particular interest and will be the only items discussed in this report.

METHODS

This report is based on data from inshore commercial shrimp fishermen volunteering for detailed interviews conducted by NMFS statistical agents. Interviews were obtained during June-September 1987 and June-October 1988 on the Gulf of Mexico coast, and August-October 1988 on the South Atlantic coast. The NMFS agents were located in selected inshore ports and statistical areas in each year, based on known distribution of inshore shrimping effort. Agents within a port area interviewed randomly selected shrimpers who volunteered information as they landed their inshore catch. In 1987 agents were present in Houma, LA (statistical area 14); Cameron, LA (area 17); Galveston, TX (area 18); Aransas Pass, TX (area 19); and Matagorda, TX (area 20). In 1988 agents were stationed in Houma and Golden Meadow, LA (area

14); Galveston, TX (area 18); Aransas Pass, TX (area 19) and North Carolina. Because there had been inadequate volunteer response from areas 16 and 17 during 1987, agents were not again assigned to these areas and no data are available from them for 1988.

Shrimpers in inshore waters reported the statistical area fished (logged on an appropriate area chart), vessel length and gear, number of tows, time per tow, port of unloading, catch data (pounds and species), and fishing effort data (hours by day and night). Both statistical data and summary monthly charts of tows were prepared for Gulf of Mexico areas. North Carolina fishermen were interviewed only in August-October of 1988, and those limited data, with towtimes and port of landing only, are considered separately.

Statistical analyses were prepared with the use of SAS programs for personal computer, including tabulate and frequency procedures (SAS® Institute Inc., 1985). Analyses of variance (ANOVA) of the highly unbalanced tow data were performed using SAS general linear models procedures (GLM). Although various data transformations were tested, (conversion of tow durations to natural logarithms, exponents and roots) to normalize both the data and the residuals, maximum r^2 were obtained using untransformed data.

The NMFS Statistical Branch has subdivided area 14 into major and minor areas for analysis of commercial catch

statistics. These areal subdidivisions were retained for some computerized statistical analyses of these tow duration data.

During this study fishermen reported use of two types of nets: standard shrimp trawls of various sizes and butterfly nets. Butterfly nets as used in inshore waters of Louisiana are 'set' in a given location for a period of time with the cod end raised periodically to remove catch. Throughout this document 'tow' and 'towtime' combine number and durations of both trawls and butterfly sets. 'Trawl' and 'trawl time' refer specifically to data obtained from fishermen using trawls as shrimping gear. Means of tow and trawl times are expressed in minutes ± one standard deviation (SD).

RESULTS

Interviews were unequally distributed between years and months. About 61% of the interviews took place in 1987, and these were divided almost equally between Louisiana and Texas ports. In 1988, however, Texas interviews constituted almost 63% of the total.

Results for the Gulf of Mexico are based on the total number of combined trawls and sets of butterfly nets recorded for each statistical subarea by month and year. A total of 13,395 tows, 12,787 trawls and 608 butterfly sets, were recorded from 4,455 trips (time of leaving dock to time to return). Of all tows, 8,159 (60.9%) were reported from 2,677 trips in 1987 and 5,236 (39.1%) from 1,778 trips in 1988 (Table 1, Fig. 1).

Tow Duration

Tow durations were frequently reported in 30 or 60 minute intervals. Mean tow duration, years combined (min ± 1 standard deviation, SD) was 119.7 ± 56.8 min (Table 1). The mean tow time of 113.5 ± 58.3 min in 1987 differed significantly from the 129.4 ± 52.9 min in 1988 (t=-16.36, p=.0001). Individual tow durations ranged from 10 to 720 min. In each year both median and mode were 120 min.

Gear

Type of gear had a significant effect on tow time. A GLM (ANOVA procedure for unbalanced data) with all tow data included considered tow duration as function of gear, year, statistical subareas and their interactions for those areas reporting both gears, and with more than one butterfly set (Areas 12-15; Table 2). Gear was the most significant single source of variation in tow duration (F=330, p=0.0001), with gear*year interaction contributing even more to the sums of squares and the variation (F=350, p=0.0001). Years combined, butterfly sets were significantly longer (190.8 ± 139.3 min) than trawls (110.6 ± 44.9 min; t=14.11, p=0.0001). Mean tow duration varied significantly with year within each gear subclass.

Butterfly Sets Occurrence of butterfly sets differed significantly both with subarea and year. Of 608 butterfly sets, 568 (93.4%) were recorded from area 14, inshore coastal Louisiana, the remaining 40 from areas 11 through 15. Use of

this gear was not reported from any Texas area. Butterfly sets were reported in both years of the survey only from statistical areas 12 and 14 (Table 3B). The number of reported sets doubled between 1987 and 1988, although the number of interviewees using this gear declined from 139 in 1987 to 120 in 1988. Of 139 butterfly shrimpers in 1987, 94 reported a single set (range 60-720 min) as against only 26 of the 120 interviewed in 1988 (range 60-480 min). The 205 sets in 1987 represented only 3.9% of that year's tows, but the 402 sets in 1988 constituted 15.4% of 2615 tows. Mean butterfly set times (Table 3B) were 252.8 ± 173.5 min in 1987 and 159.3 ± 104.9 min in 1988 ($t=7.10$, $p=.0001$), with subarea means ranging between 225 and 413 min in 1987 and 120 to 263 min in 1988.

Trawls Mean trawl times (all subareas included) were 109.9 ± 46.8 min in 1987 and 126.9 ± 45.1 in 1988 ($t=-20.45$, $p=0.0001$) and ranged, by statistical area, between 105 and 166 min in 1987, and 103 to 157 min in 1988 (Table 3A, Fig. 2).

Frequency of Tows Less Than 90 Minutes

Regulations implemented in 1990 require the use of TEDs in inshore waters when shrimpers trawl longer than 90 min. Of all 1987-1988 inshore trawls reported here, 35% of Gulf of Mexico inshore trawls (41% in 1987, 26% in 1988) were reported to be 90 min or less (Table 4). Including both gears reduced the percentage of shorter tows only slightly (34% overall: 40% in 1987, 25% in 1988; Table 4A). Differences both in mean trawl time and in frequency of trawls less than 90 min (Fig. 3) may in

part reflect a change in sampling distribution between the two years (Table 5; Fig. 1).

Variation with Area and Year

The most tows both by number and by percentage were from Louisiana waters of area 14. About 63% (5131) of 8151 tows in 1987 were from that area as against 41% (2167 of 5236 tows) in 1988. Fewer trawls were recorded in 1988 from Texas area 19 (1582 in 1987 and 1241 in 1988; Table 5). Sampling was greatly increased from Louisiana area 13, however, (112 tows in 1987 to 714 in 1988), and to a lesser extent Texas area 18 (780 in 1987 to 895 in 1988). As explained above, no data were obtained from either area 16 or area 17 in 1988.

A GLM procedure (ANOVA for unbalanced data) considered tow duration as a function of gear, year, area, and their interactions; only areas with data from both years and more than 10 tows were included (areas 12, 13, 14, 15, 18, 19, and 20; Table 6A). The r^2 value was low (0.2020), but mean duration varied significantly with gear, subarea sampled, year, year*subarea and gear*subarea interaction for combined gears (pr>F=0.0001). Elimination of the gear component further reduced r^2 (0.1376). Mean duration for trawls alone yielded significant components for subarea, year and subarea*year (p>F 0.0001).

Louisiana coastal waters of area 14 exhibited the most marked differences in sampling and gear. In 1987, 60% (4747) of 7951 trawls were from that area as against only 29% (1415) of 4834 trawls in 1988 (Fig. 1). Butterfly sets were also most numerous

in that area. The 192 butterfly sets from area 14 in 1987 represented 4.0% of that year's area 14 tows, but the 376 sets in 1988 constituted 20.9% of 1791 tows. Within this subarea, as in the overall analysis, both mean towtime (both gears included) and mean trawl times differed significantly between years (Tables 7A and 7B). The mean trawl time of 104.6 ± 45.8 min, with the 25% quantile at 60 min in 1987, increased to 110.7 ± 29.5 min in 1988 with the 25% quantile at 90 min (Table 2A, Fig. 4). There was a concurrent change in frequency of trawls less than 90 minutes (Table 8). In 1987, 2179 of 4747 area 14 trawls (45.9%) were less than 90 minutes, as against 517 of 1415 (36.5%) in 1988 (Fig. 5).

Because of the detailed areal divisions and the large number of tows recorded, some analyses examined area 14 by subdivision. Mean annual trawl times of 90 min or less were recorded from 6 areal subdivisions in 1987: 14.11, 14.25, 14.31, 14.32, 14.41, and 14.43 (Table 7A). The 1660 trawls from these subdivisions represented 34.7% of the 4787 trawls reported. In 1988 only subareas 14.35 and 14.41 (168 trawls; 11.9% of 1415) recorded mean trawl durations less than 90 min.

There were no trawls reported in 1988 from several minor areas within statistical area 14 (Table 7A, Fig.4). The GLM procedure for tows was therefore based on major subdivisions to reduce the number of empty cells (Table 9A). The r^2 was slightly less than that within the Gulf of Mexico as a whole (0.1863). Mean tow duration differed significantly with area, year, and

year*area interaction, but not with gear. A similar procedure for trawls alone yielded an r^2 of only 0.05 with significant F for year, area, and their interactions.

The variation in trawl duration between statistical areas was readily apparent when inshore trawls from Louisiana area 14 (Fig. 6) and Texas waters (Fig. 7) were compared by 30 minute intervals. Shrimpers from both areas reported most trawls to be 120 min, but Louisiana shrimpers reported more than 29% of trawls of 60 min, against 12 % in Texas waters. Conversely, Texas shrimpers reported that almost 24% of trawls were 180 min as contrasted to less than 10% of Louisiana inshore trawls.

Mean trawltime decreased significantly in area 18 (Galveston Bay area) during 1988 as compared to 1987 (102.6 ± 36.1 vs 132.1 ± 62.1), while increasing in both 13 (Mississippi delta) and 19 (Matagorda, TX; area 13:125.5 ± 38.6 vs 136.5 ± 41.9; area 19:106.3 ± 43.0 vs 156.6 ± 45.5).

Changes with Month

Sampling distribution also varied with month (Table 10). Combining both years, most tows were recorded in June (3978), followed by August (3510), September (3100), July (2410) and October (839; sampled only in 1988). Tows less than 90 minutes also followed this monthly pattern, while tows longer than 90 minutes were of approximately equal frequency in all months but June and October (Table 11). Although mean towtime differed between sampling months, median and mode were 120 min in all but one of the 10 months. Quantile 25, however, was 90 min or less in

each month of 1987 as well as in June, 1988 but reached 120 min in each of the remaining months of 1988. In July 1988 not only did quantile 25 reach 120 min but both median and mode were 180 min. Mean towtime of 154.8 ± 49.0 (731 tows) in July 1988 was the highest in any month (Appendix, Table 1).

Vessel Length

Analysis of the data by vessel length revealed a marked difference in distribution of fishing vessels by size between the two most heavily fished areas: inshore Louisiana and inshore Texas. Only 1% of those Texas shrimpers landing catch at docks sampled by NMFS statistical agents were fishing from boats 25 ft or less (Table 12A, Fig.8) vs 47% of Louisiana shrimpers (Table 12B). By far the highest percentage (60%) of Texas shrimpers used vessels 38-50 ft, with 22% of Louisiana fisherman reporting that size vessel.

North Carolina

Results from North Carolina differ sharply from those of the Gulf of Mexico. Representing only 310 tows landed in the three counties Cartaret (9), Hyde (27) and Pamlico (37), overall mean towtime was 87 ± 33.6 min (Table 13), with range from 45 to 180 min. Neither differences between months nor between two of the ports of landing were statistically significant. Although the mean 109.9 ± 37.4 for Hyde (27) is higher, it is based on only 53 tows. More than 81 % of reported tows were less than 90 min (Table 14), and tows longer than 90 minutes were more frequent in the fall months of September and October (Fig. 9).

DISCUSSION

There are several possible sources of error in analyses of these survey data. Criteria for randomized statistical sampling have not been met and responses by shrimpers were voluntary. Further, numbers of interviews varied both between the two primary coastal areas sampled (Louisiana and Texas) and the two years. Local shrimping practices may have exaggerated variations due to differences in numbers of interviews. For example, Louisiana shrimpers using butterfly nets may have reported only the total time the net was in the water rather than each retrieval of the cod end. Further, tow duration estimations by informants tended to be in units of half or whole hours.

Examination of these data suggest that most Gulf of Mexico inshore fishermen do not at present conform to practices that would permit trawling without TEDs. Tow times are usually longer than 90 minutes (a mode of 120 min, longer in some months). Inshore vessels in Texas are beyond the 25 ft permitted for non-TED fishing, but almost half the Louisiana vessels were below this value. Thus, major changes in fishing practice may be required for these shrimpers to conform to TED regulations. Fewer modifications may be needed in the South Atlantic, if the limited data from North Carolina is truly representative. Close supervision may be required to ensure that shrimpers conform to the regulations.

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SUMMARY

1. Interview data from Gulf of Mexico inshore shrimp fishermen were collected during May through September, 1987 and June through October, 1988.

2. 13,395 tows, consisting of 12,787 trawls and 608 butterfly net sets, from 4,455 trips were analyzed for mean towtime and frequency of tows less than 90 min.

3. Overall the mean inshore trawltime Gulf wide was 116.3 min, 110 min in 1987 and 127 min in 1988, with ranges from 10 to 720 min.

4. Butterfly sets were significantly longer than trawls, 191.3 min overall, 253 min in 1987 and 159 min in 1988. Butterfly sets occurred only in Louisiana waters and 96% were recorded from area 14.

5. Thirty-five per cent of all tows were less than 90 min, 41% in 1987 and 26% in 1988.

6. There was a shift in sampling between years, with Louisiana inshore areas contributing 4747 of 7951 trawls in 1987 but only 1415 of 4834 trawls in 1988.

7. Louisiana shrimpers reported 45% of tows less than 90 minutes during 1987, but only 32% below this value in 1988.

8. Distribution of towtimes differed between Louisiana and Texas inshore waters. Both groups reported 120 min as most frequent tow time, but 60 min tows were second in frequency in Louisiana. The second most frequent towtime in Texas was 180 min.

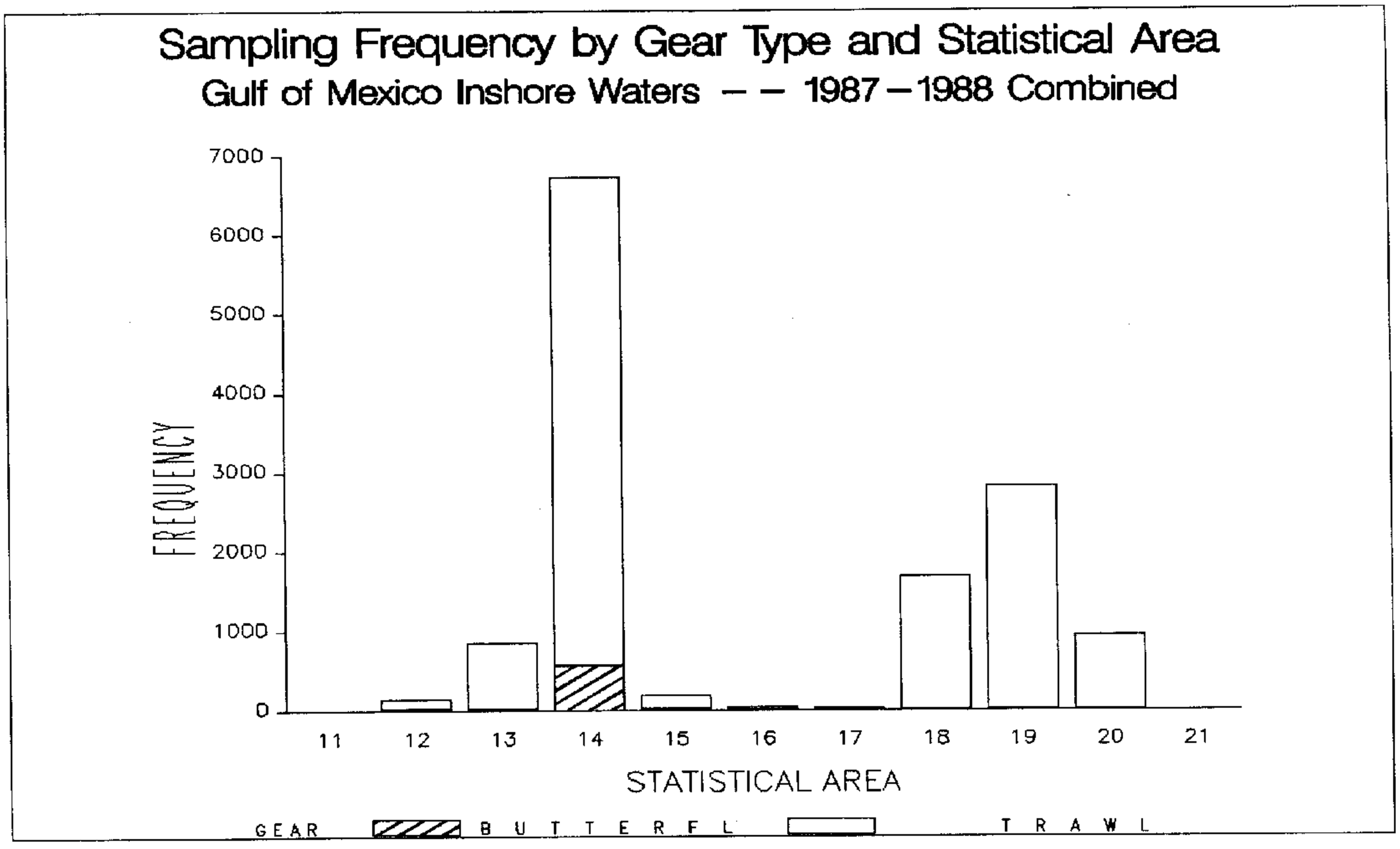
9. Disregarding area, mean towtime differed both between years and between months. Mean towtime was longest (155 min) in July, 1988. When statistical area was included in the analysis, annual differences were not statistically significant.

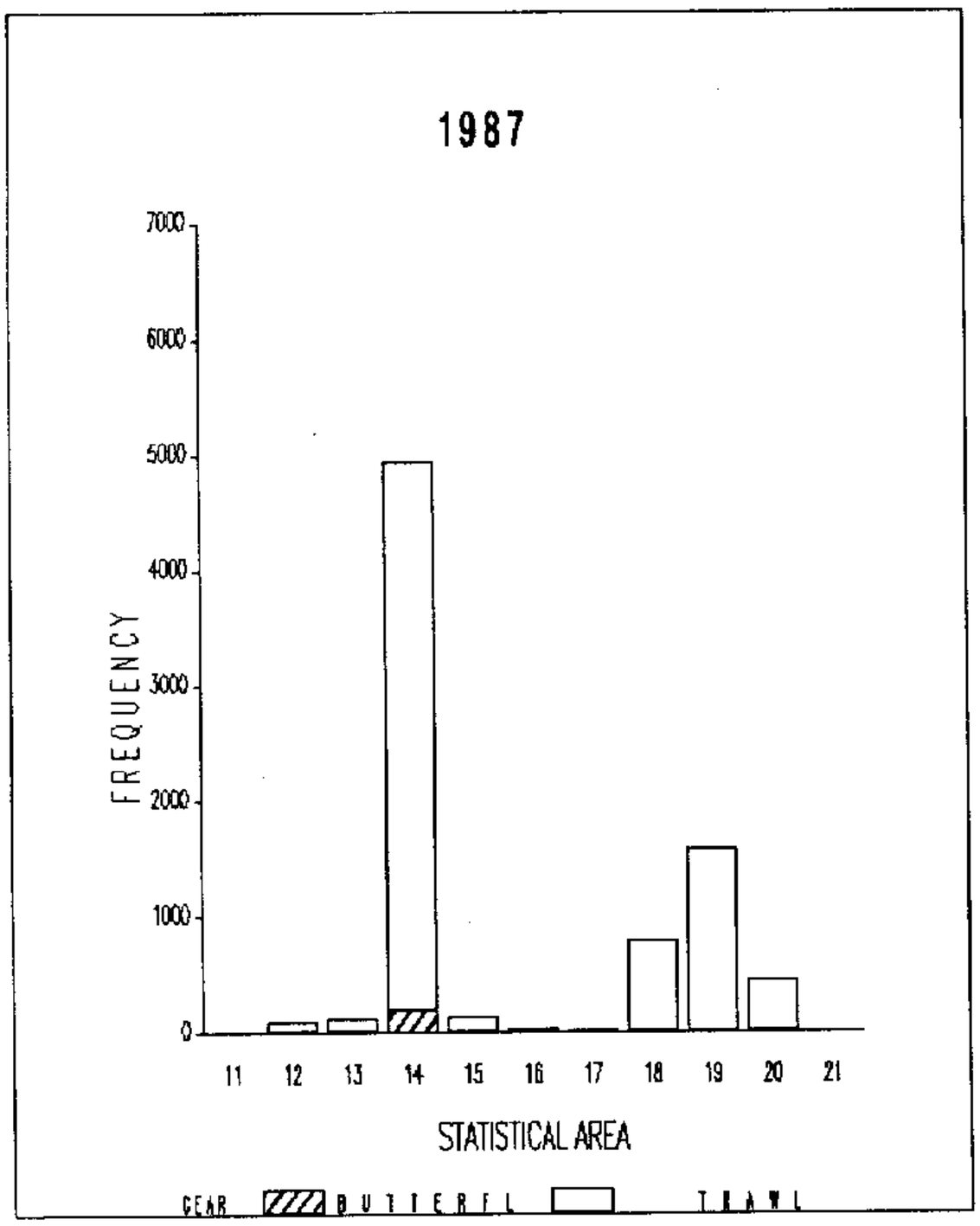
10. Vessel lengths differed significantly between Texas and Louisiana. Fewer than 1% of Texas inshore vessels landing at commercial shrimp docks were less than 25 ft, as opposed to 47% of those operating in Louisiana. The majority of Texas shrimpers (61%) fished in vessels between 38 and 50 ft.

11. Very limited data from North Carolina showed a mean towtime of 89 minutes for August-October 1988.

12. These data suggest that major changes in shrimping practices will be required for Gulf of Mexico inshore shrimpers to conform to proposed TED regulations.

FIG. 1


Sampling Frequency by Gear Type and Statistical Area
Gulf of Mexico Inshore Waters -- 1987-1988 Combined
FREQUENCY
7000
6000
5000
4000
3000
2000
1000
0
11
12
13
14
15
16
17
18
19
20
21
STATISTICAL AREA
GEAR
BUTTERFL
TRAWL


1987
FREQUENCY
7000
6000
5000
4000
3000
2000
1000
0
11
12
13
14
15
16
17
18
19
20
21
STATISTICAL AREA
GEAR
BUTTERFL
TRAWL

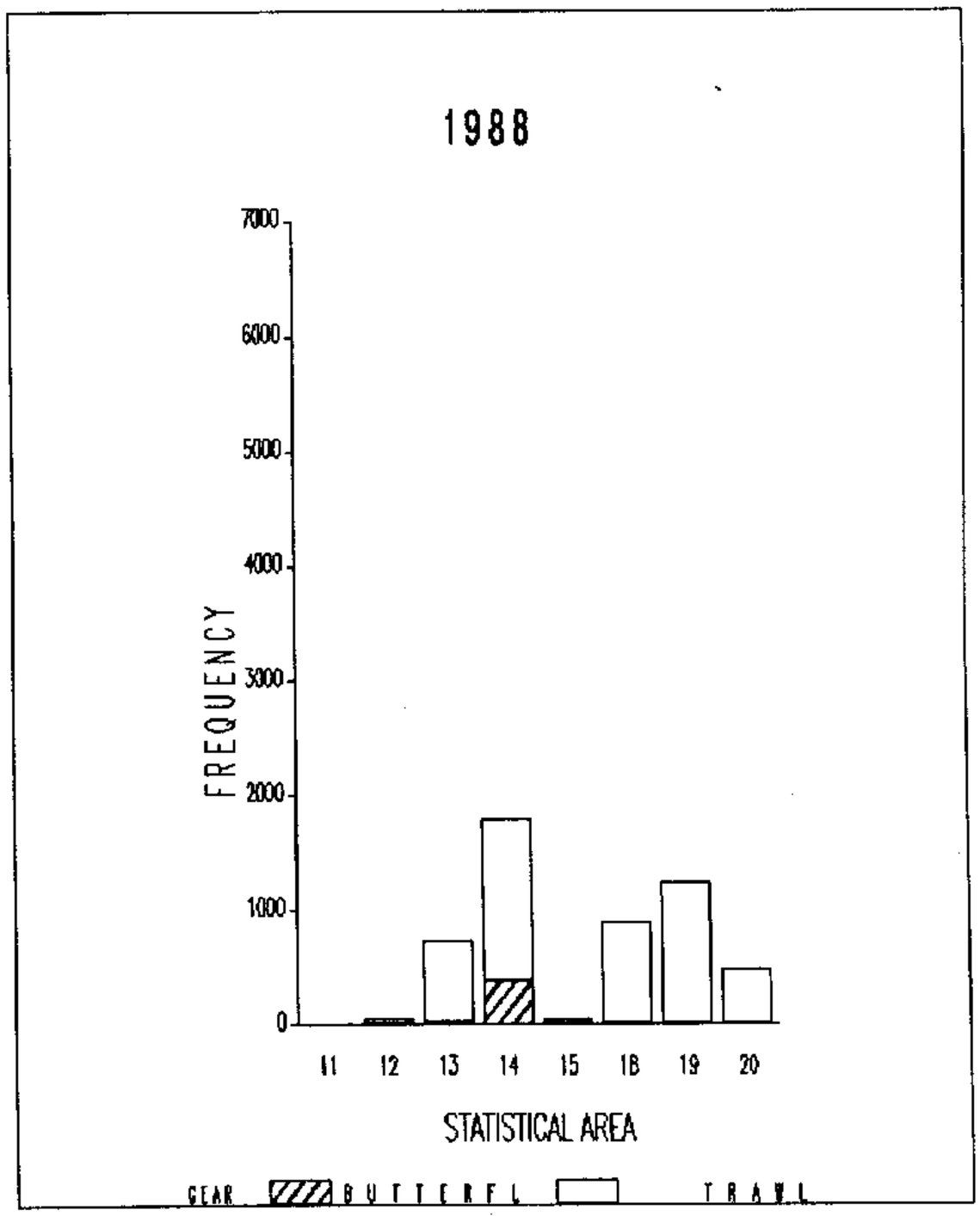
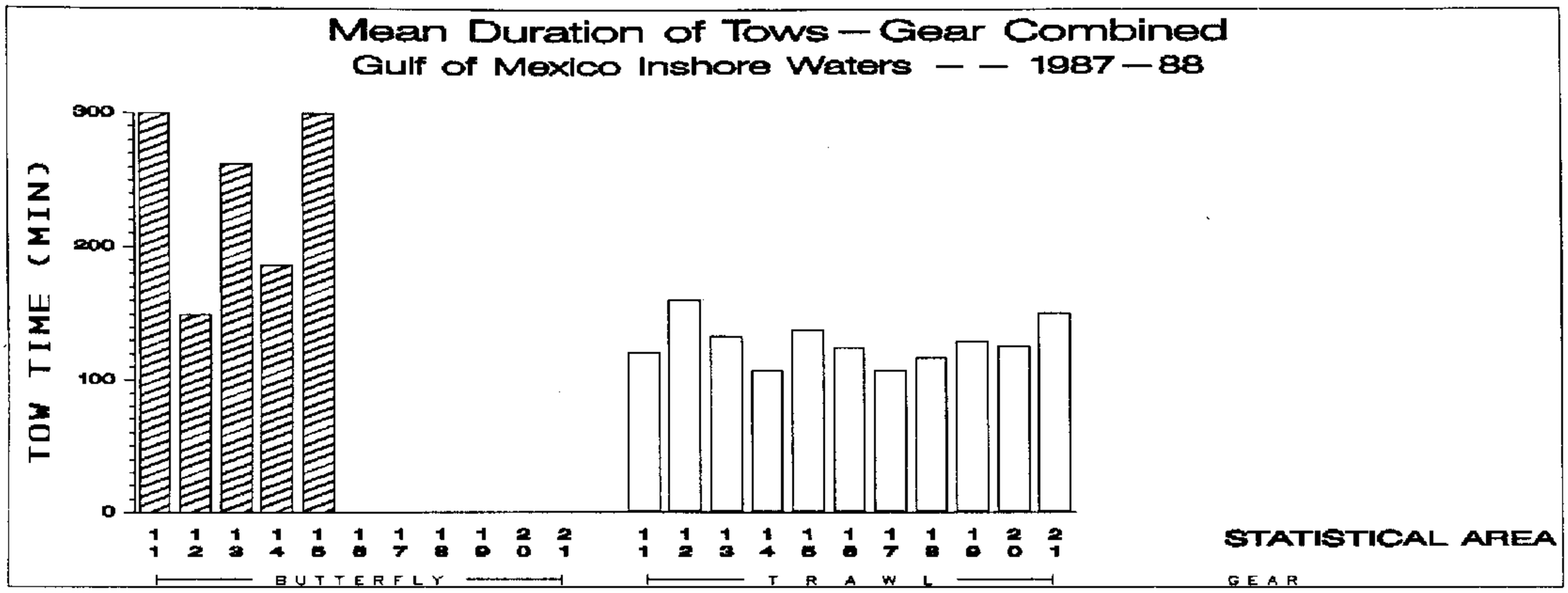
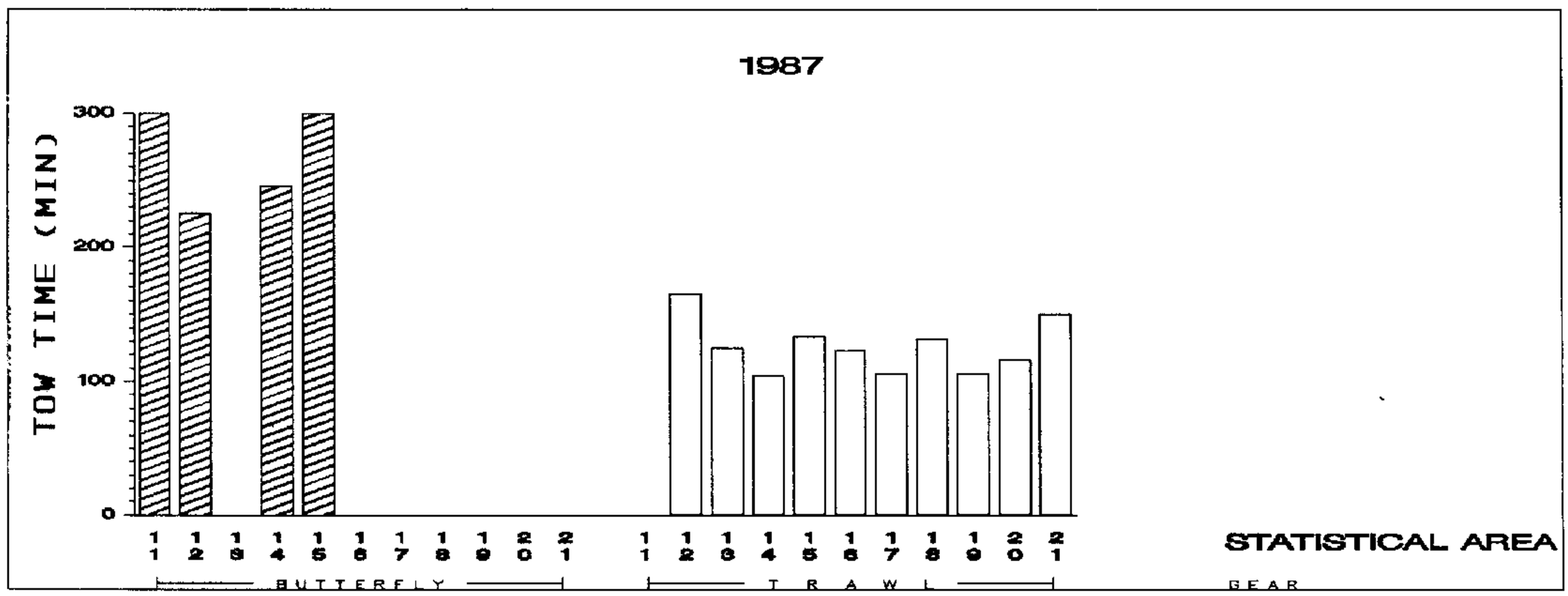

1988
FREQUENCY
7000
6000
5000
4000
3000
2000
1000
0
11
12
13
14
15
16
19
20
STATISTICAL AREA
GEAR
BUTTERFL
TRAWL

FIG. 2


Mean Duration of Tows — Gear Combined
Gulf of Mexico Inshore Waters — — 1987 — 88
TOW TIME (MIN)
300
200
100
0
11 12 13 14 15 16 17 18 19 20 21
BUTTERFLY
11 12 13 14 15 16 17 18 19 20 21
TRAWL
STATISTICAL AREA
GEAR


1987
TOW TIME (MIN)
300
200
100
0
11 12 13 14 15 16 17 18 19 20 21
BUTTERFLY
11 12 13 14 15 16 17 18 19 20 21
TRAWL
STATISTICAL AREA
GEAR

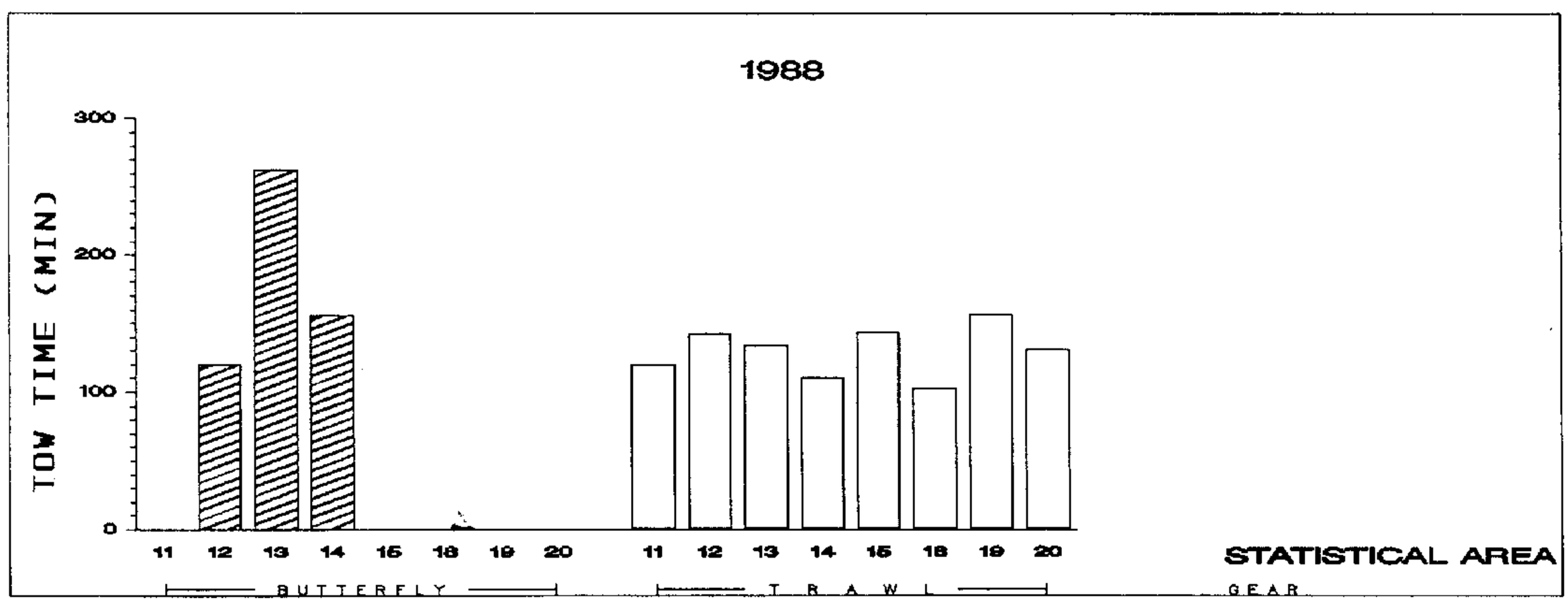
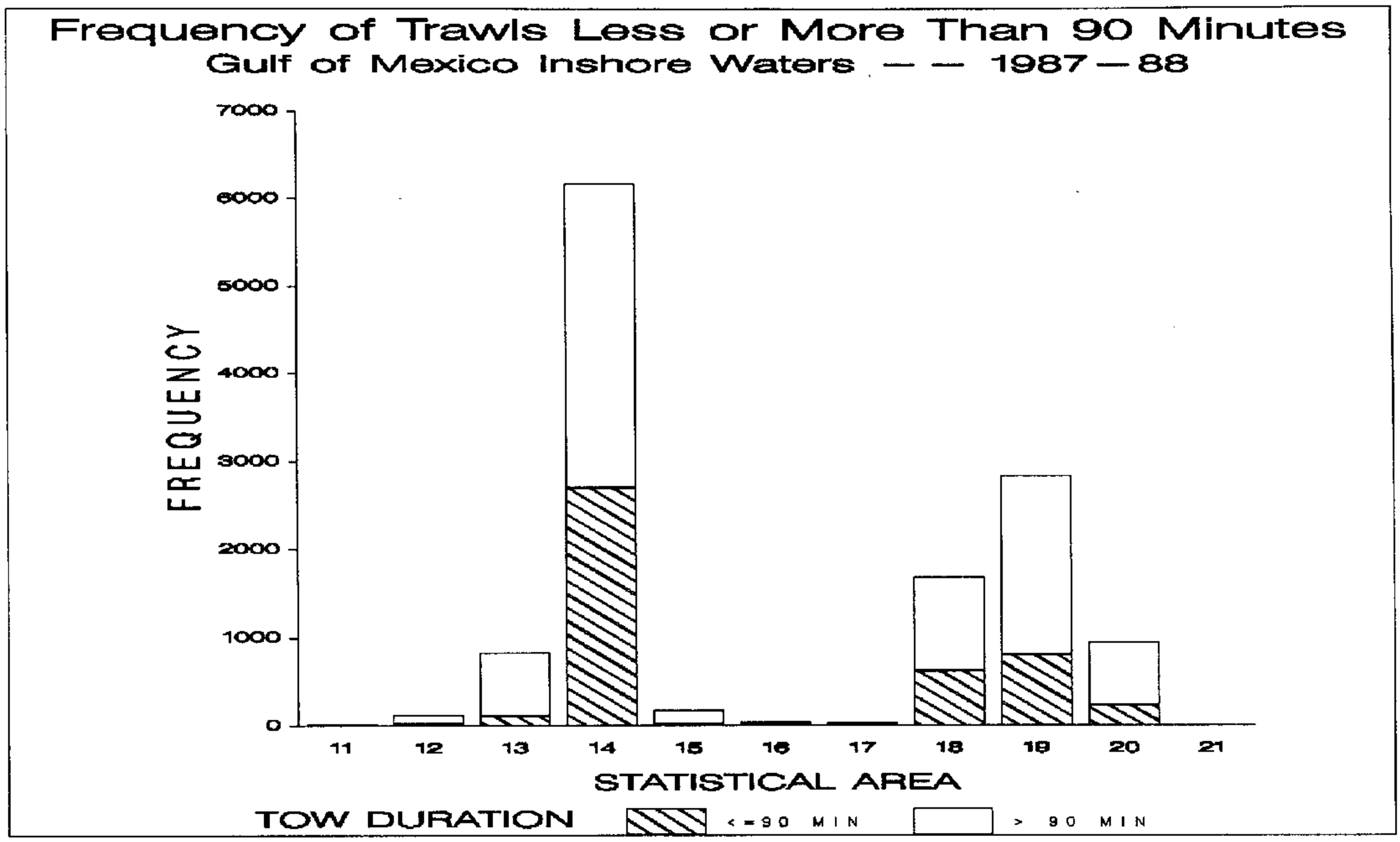
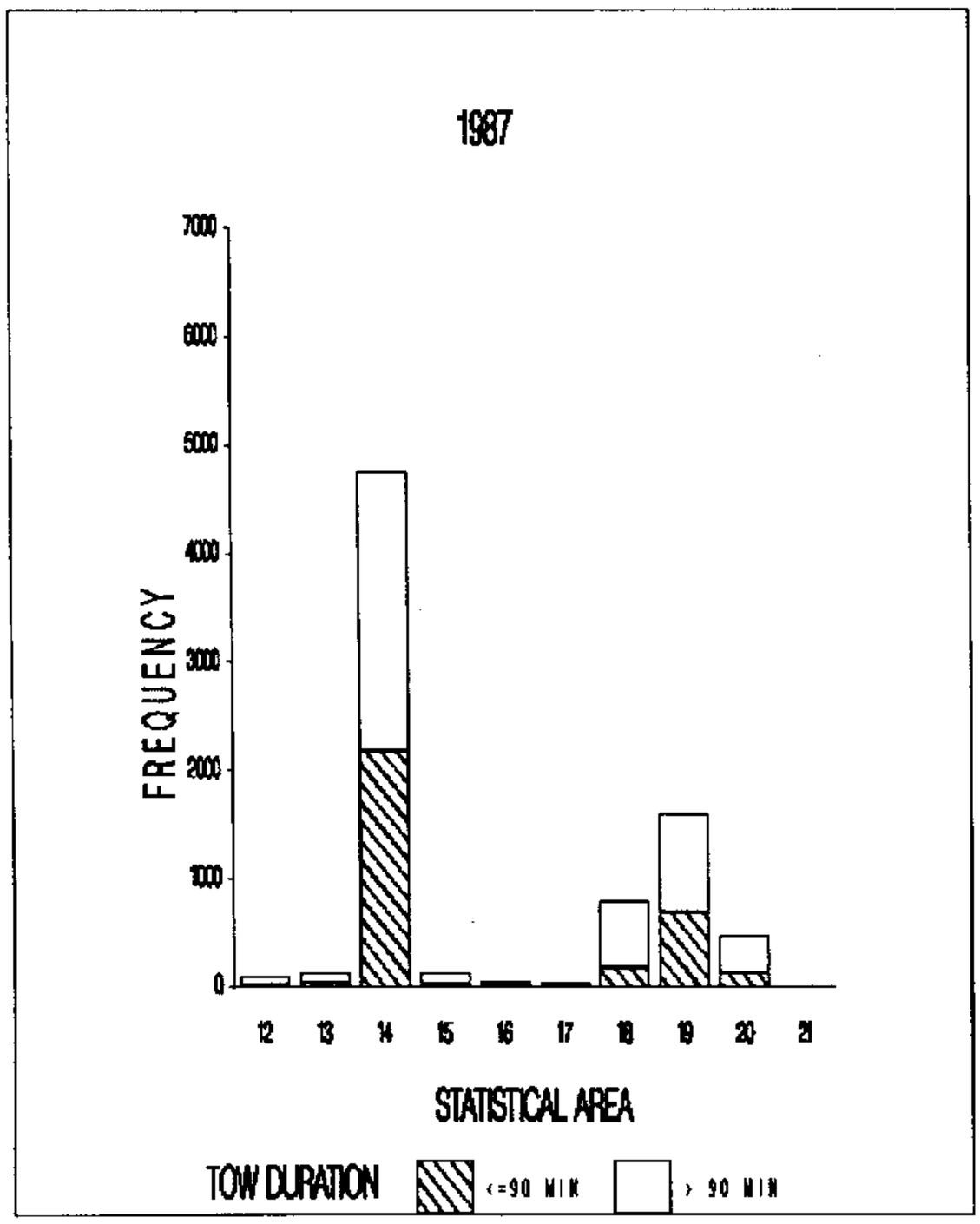

1988
TOW TIME (MIN)
300
200
100
0
11 12 13 14 15 16 19 20
BUTTERFLY
11 12 13 14 15 16 19 20
TRAWL
STATISTICAL AREA
GEAR

FIG. 3


Frequency of Trawls Less or More Than 90 Minutes
Gulf of Mexico Inshore Waters — — 1987—88
FREQUENCY
7000
6000
5000
4000
3000
2000
1000
0
11
12
13
14
15
16
17
18
19
20
21
STATISTICAL AREA
TOW DURATION
<=90 MIN
> 90 MIN


1987
FREQUENCY
7000
6000
5000
4000
3000
2000
1000
0
12
13
14
15
16
17
18
19
20
21
STATISTICAL AREA
TOW DURATION
<=90 MIN
> 90 MIN

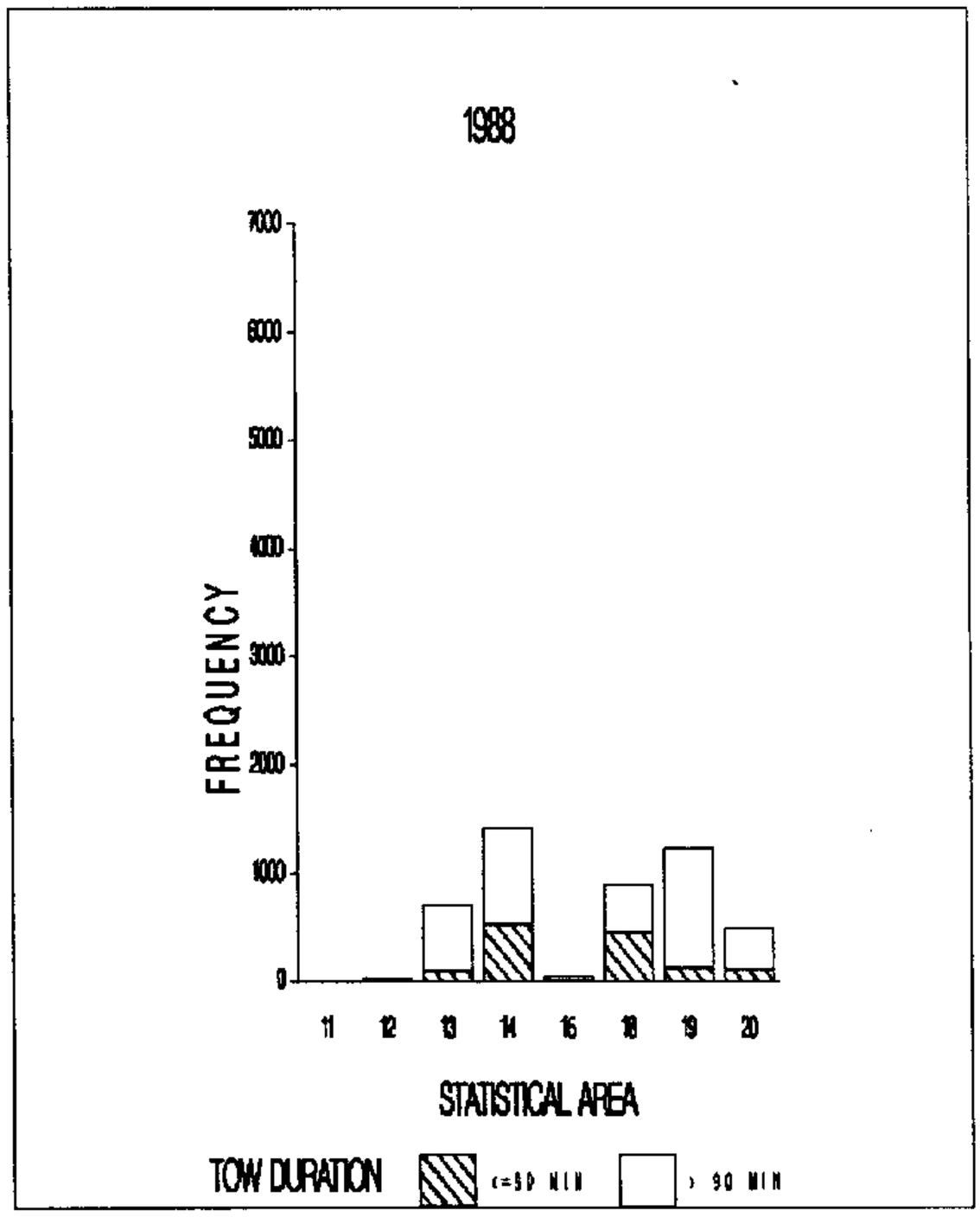
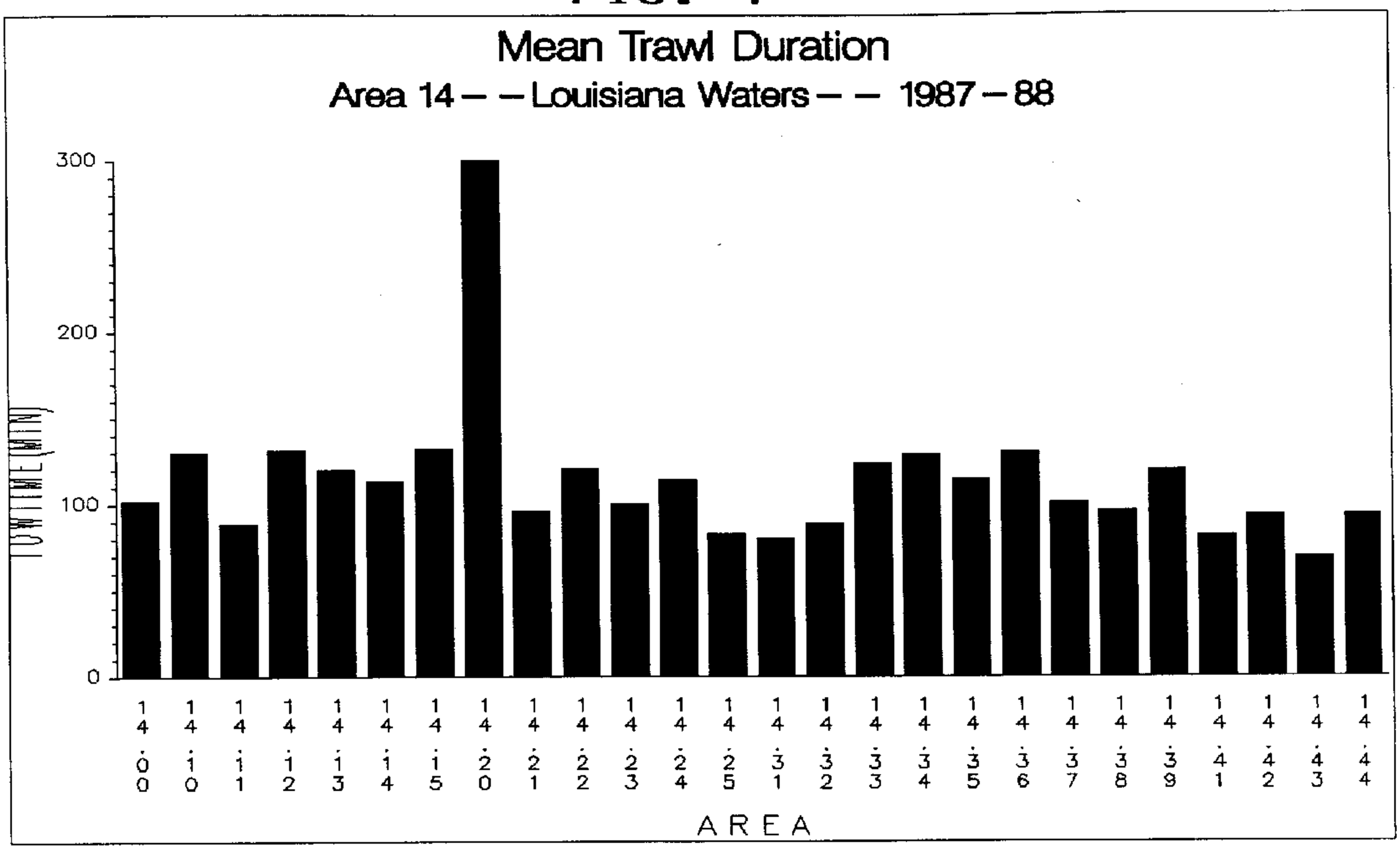
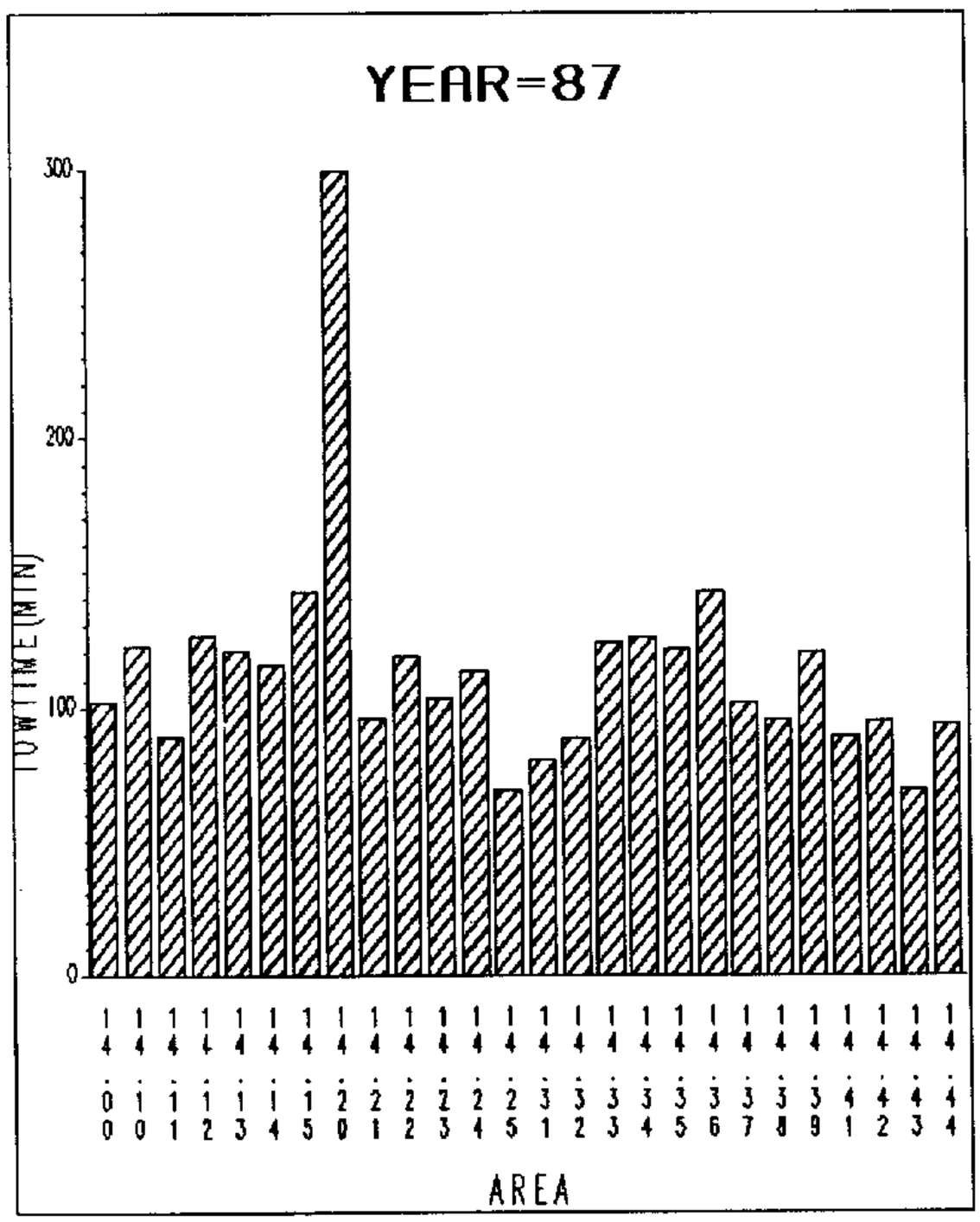

1988
FREQUENCY
7000
6000
5000
4000
3000
2000
1000
0
11
12
13
14
15
18
19
20
STATISTICAL AREA
TOW DURATION
<=90 MIN
> 90 MIN

FIG. 4


Mean Trawl Duration
Area 14 – – Louisiana Waters – – 1987 – 88
TOWTIME(MIN)
300
200
100
0
14.00
14.10
14.11
14.12
14.13
14.14
14.15
14.20
14.21
14.22
14.23
14.24
14.25
14.31
14.32
14.33
14.34
14.35
14.36
14.37
14.38
14.39
14.41
14.42
14.43
14.44
AREA


YEAR=87
TOWTIME(MIN)
300
200
100
0
14.00
14.10
14.11
14.12
14.13
14.14
14.15
14.20
14.21
14.22
14.23
14.24
14.25
14.31
14.32
14.33
14.34
14.35
14.36
14.37
14.38
14.39
14.41
14.42
14.43
14.44
AREA

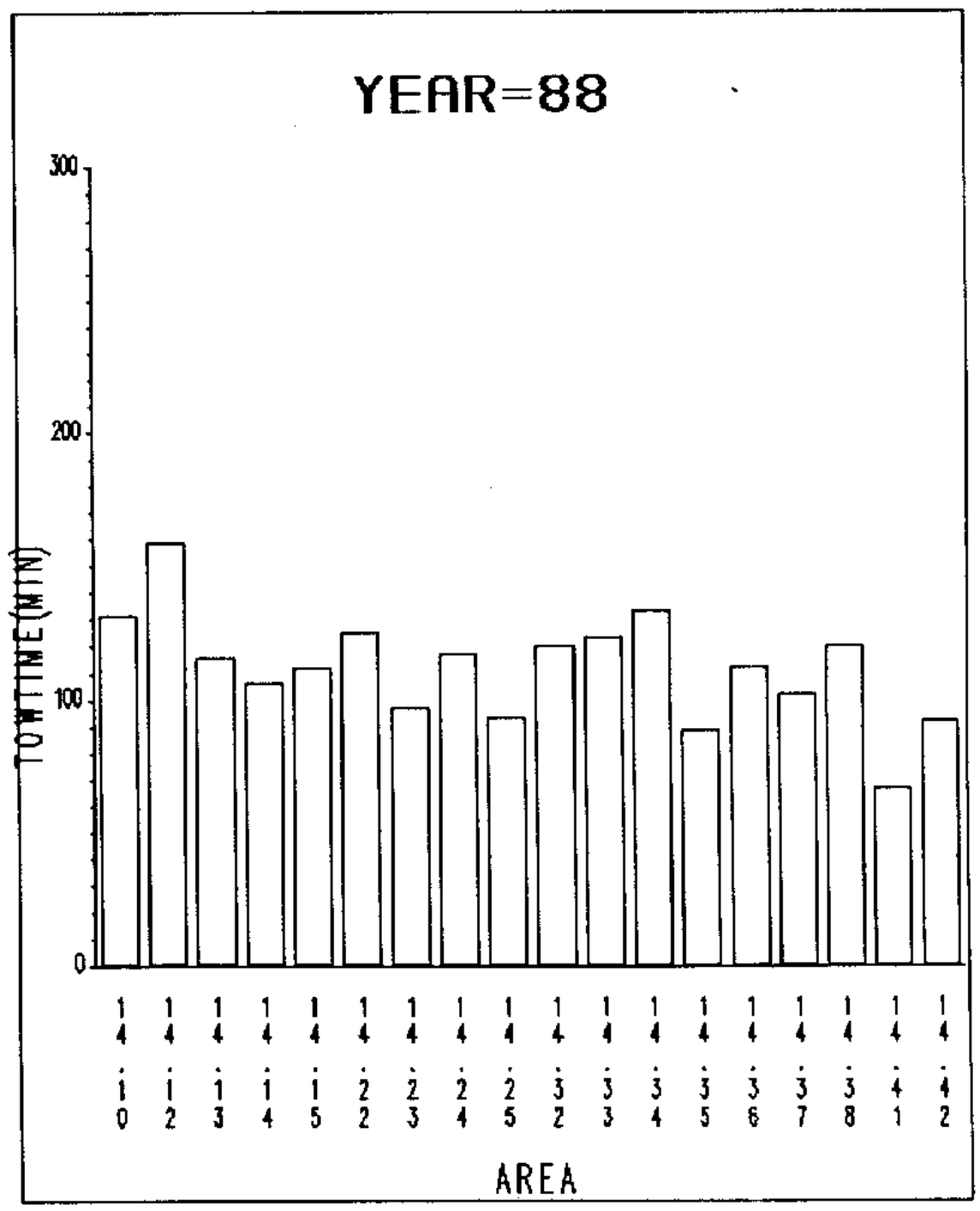
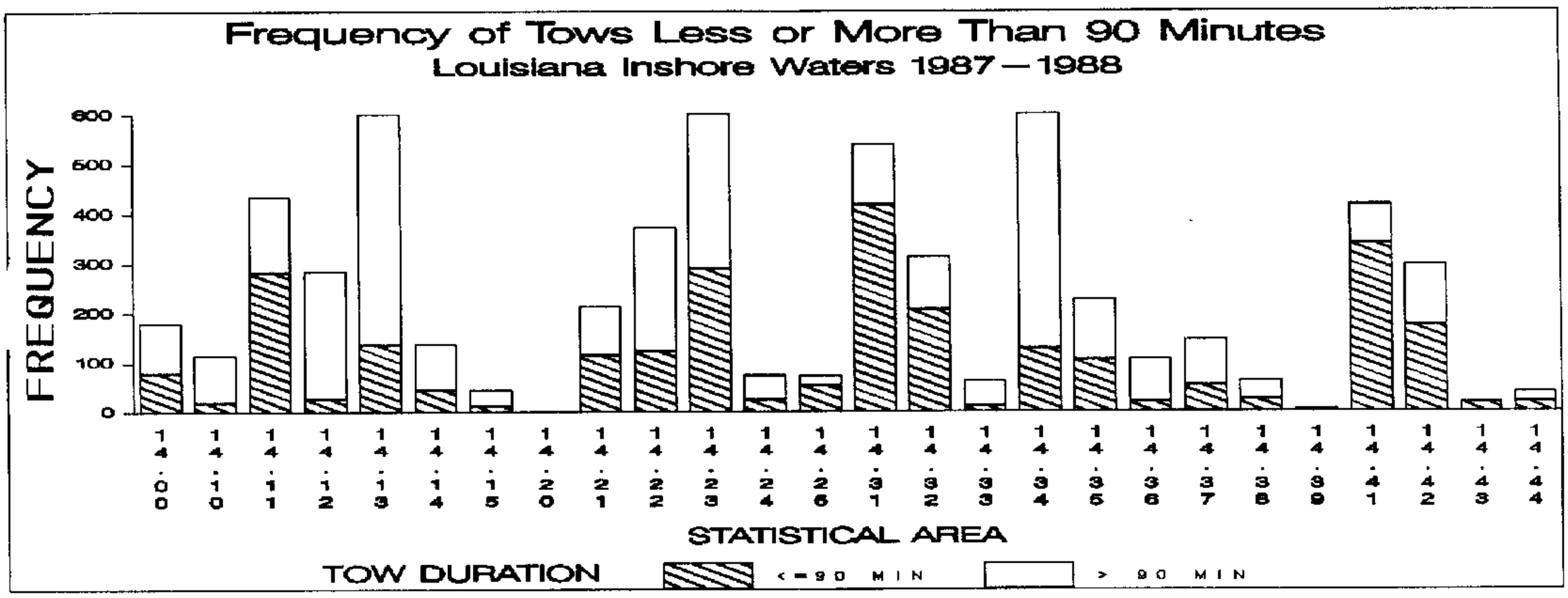
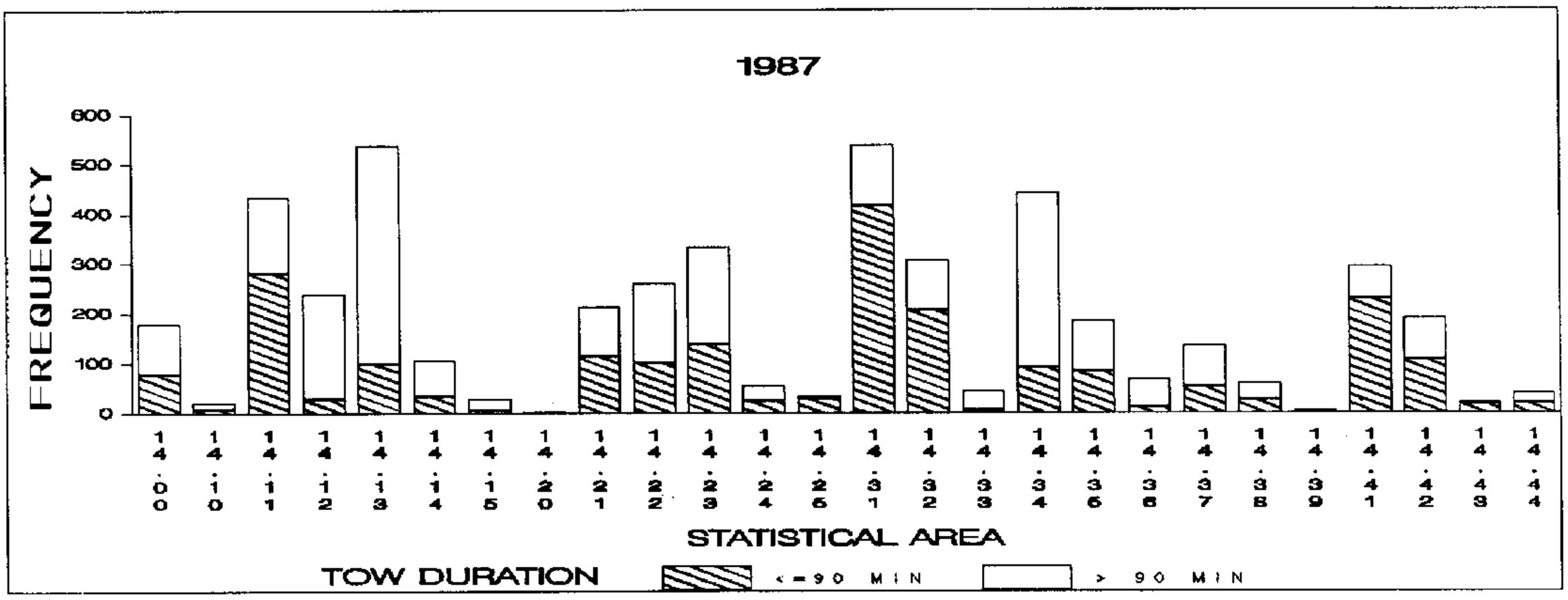

YEAR=88
TOWTIME(MIN)
300
200
100
0
14.10
14.12
14.13
14.14
14.15
14.22
14.23
14.24
14.25
14.32
14.33
14.34
14.35
14.36
14.37
14.38
14.41
14.42
AREA

FIG. 5


Frequency of Tows Less or More Than 90 Minutes
Louisiana Inshore Waters 1987—1988
FREQUENCY
600
500
400
300
200
100
0
14.00 14.10 14.11 14.12 14.13 14.14 14.15 14.20 14.21 14.22 14.23 14.24 14.26 14.31 14.32 14.33 14.34 14.35 14.36 14.37 14.38 14.39 14.41 14.42 14.43 14.44
STATISTICAL AREA
TOW DURATION
<=90 MIN
> 90 MIN


1987
FREQUENCY
600
500
400
300
200
100
0
14.00 14.10 14.11 14.12 14.13 14.14 14.15 14.20 14.21 14.22 14.23 14.24 14.26 14.31 14.32 14.33 14.34 14.35 14.36 14.37 14.38 14.39 14.41 14.42 14.43 14.44
STATISTICAL AREA
TOW DURATION
<=90 MIN
> 90 MIN

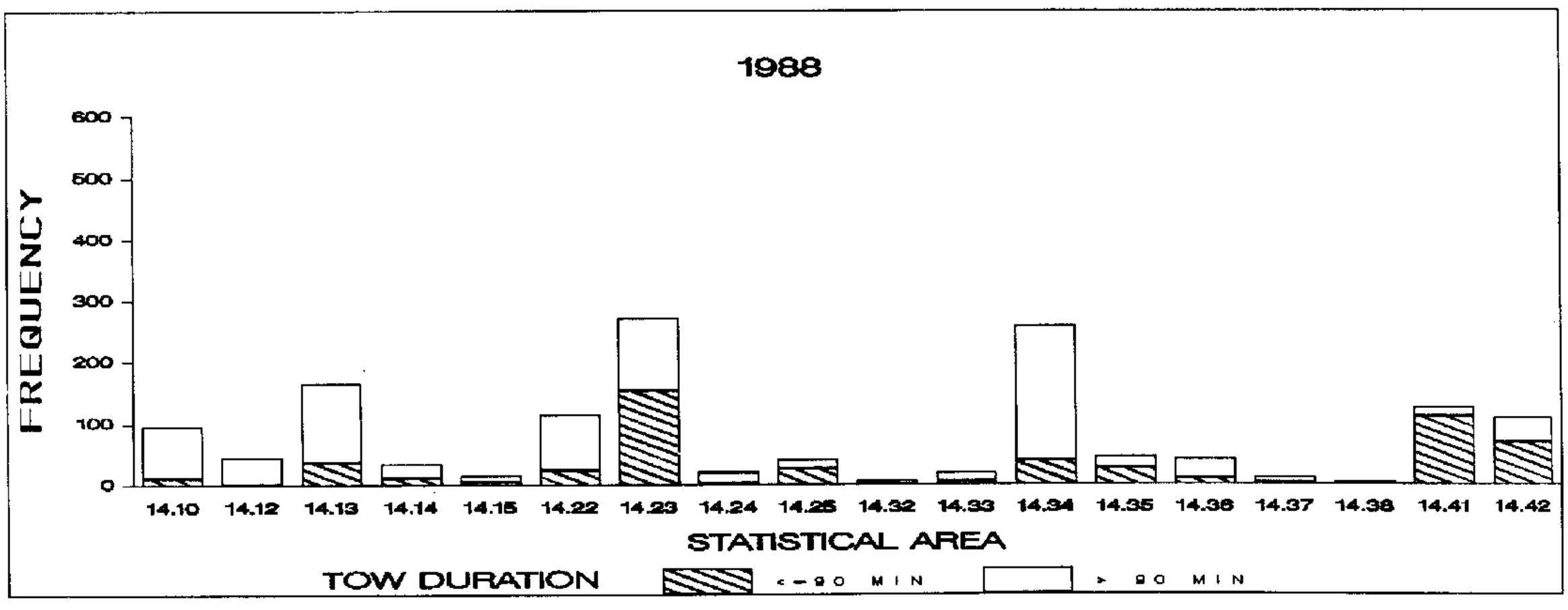

1988
FREQUENCY
600
500
400
300
200
100
0
14.10 14.12 14.13 14.14 14.15 14.22 14.23 14.24 14.26 14.32 14.33 14.34 14.35 14.36 14.37 14.38 14.41 14.42
STATISTICAL AREA
TOW DURATION
<=90 MIN
> 90 MIN

FIG. 6

Frequency of Trawl Durations by 30 Minute Intervals

Louisiana Area 14 -- 1987-1988

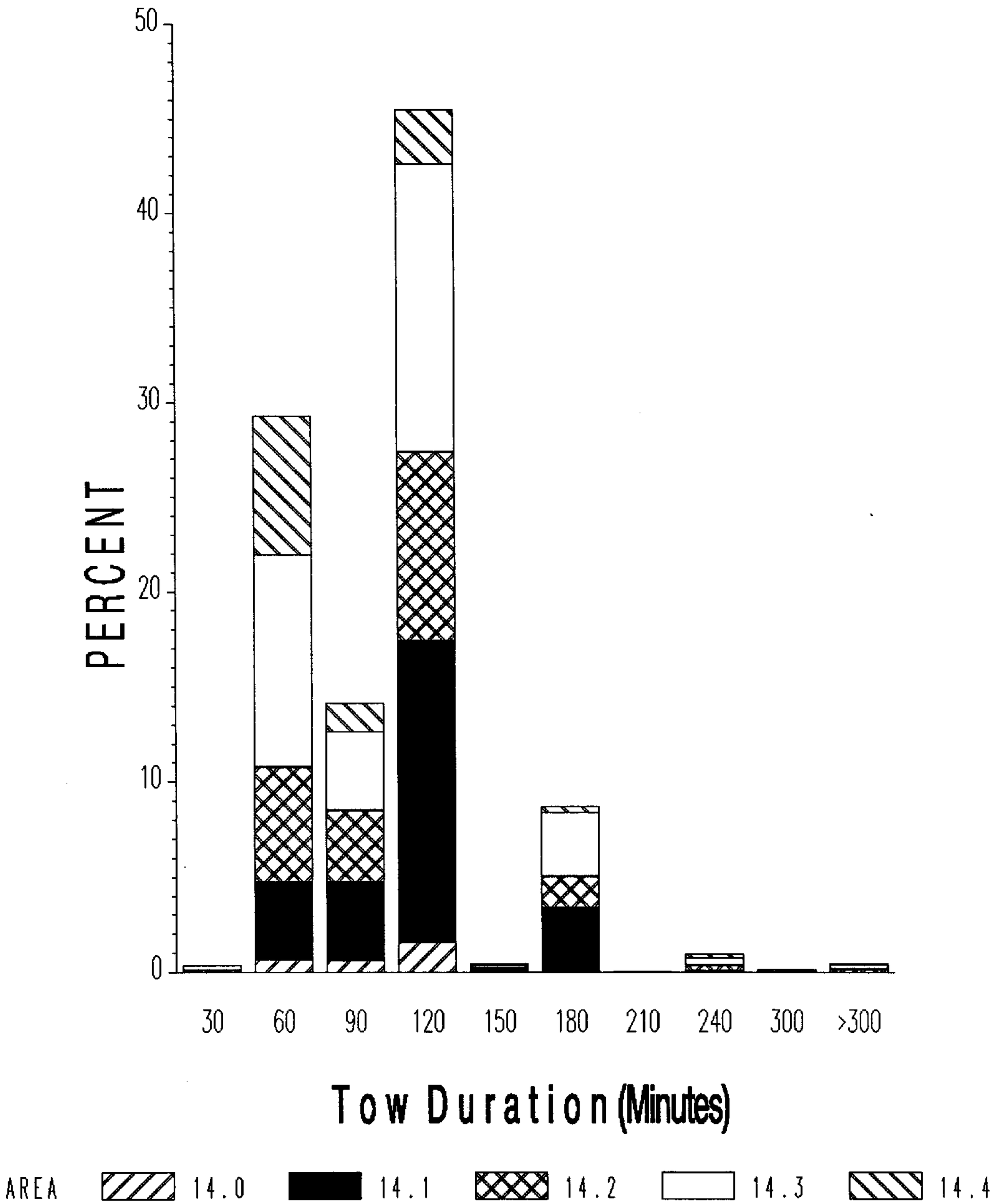
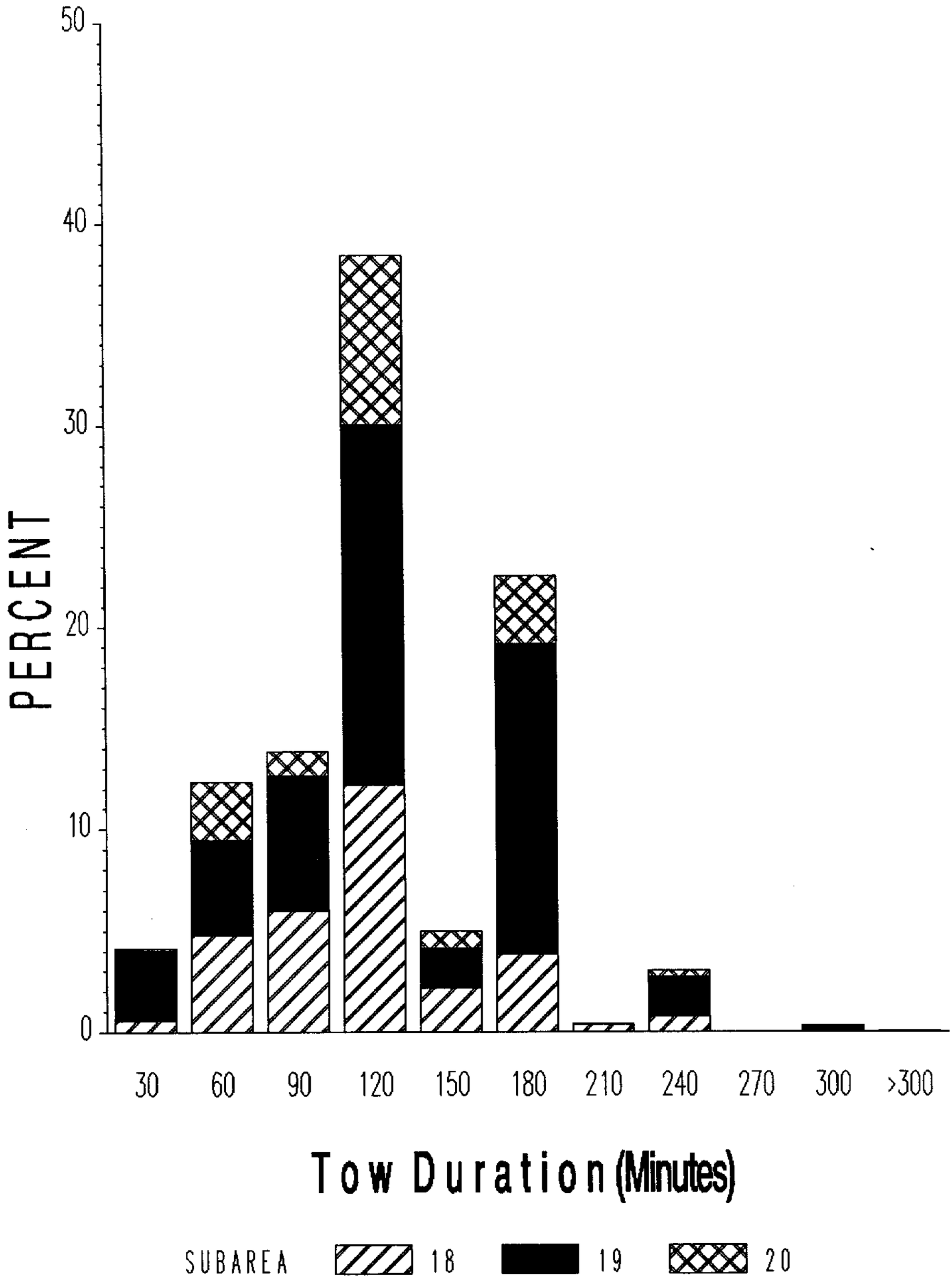


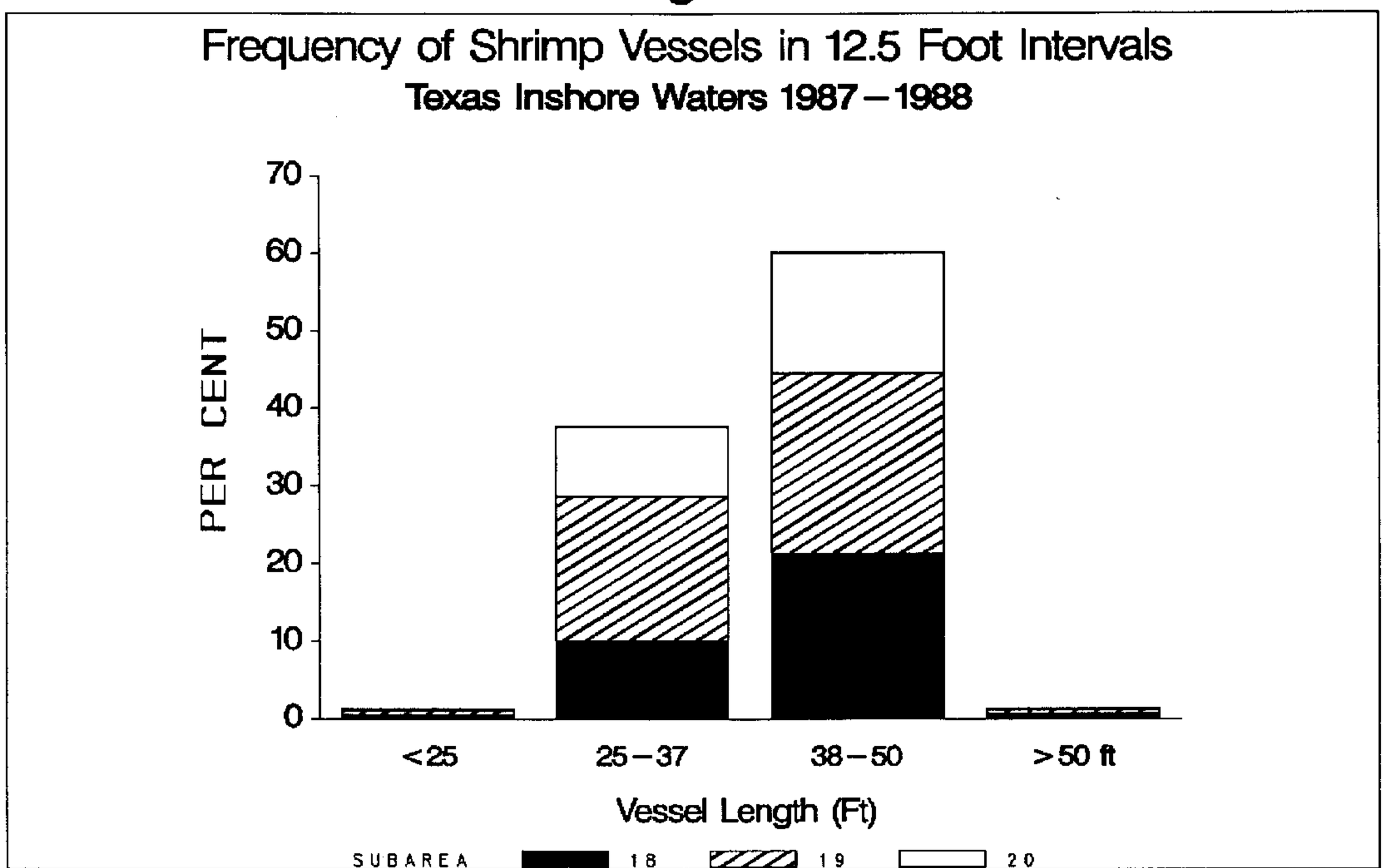
FIG. 7

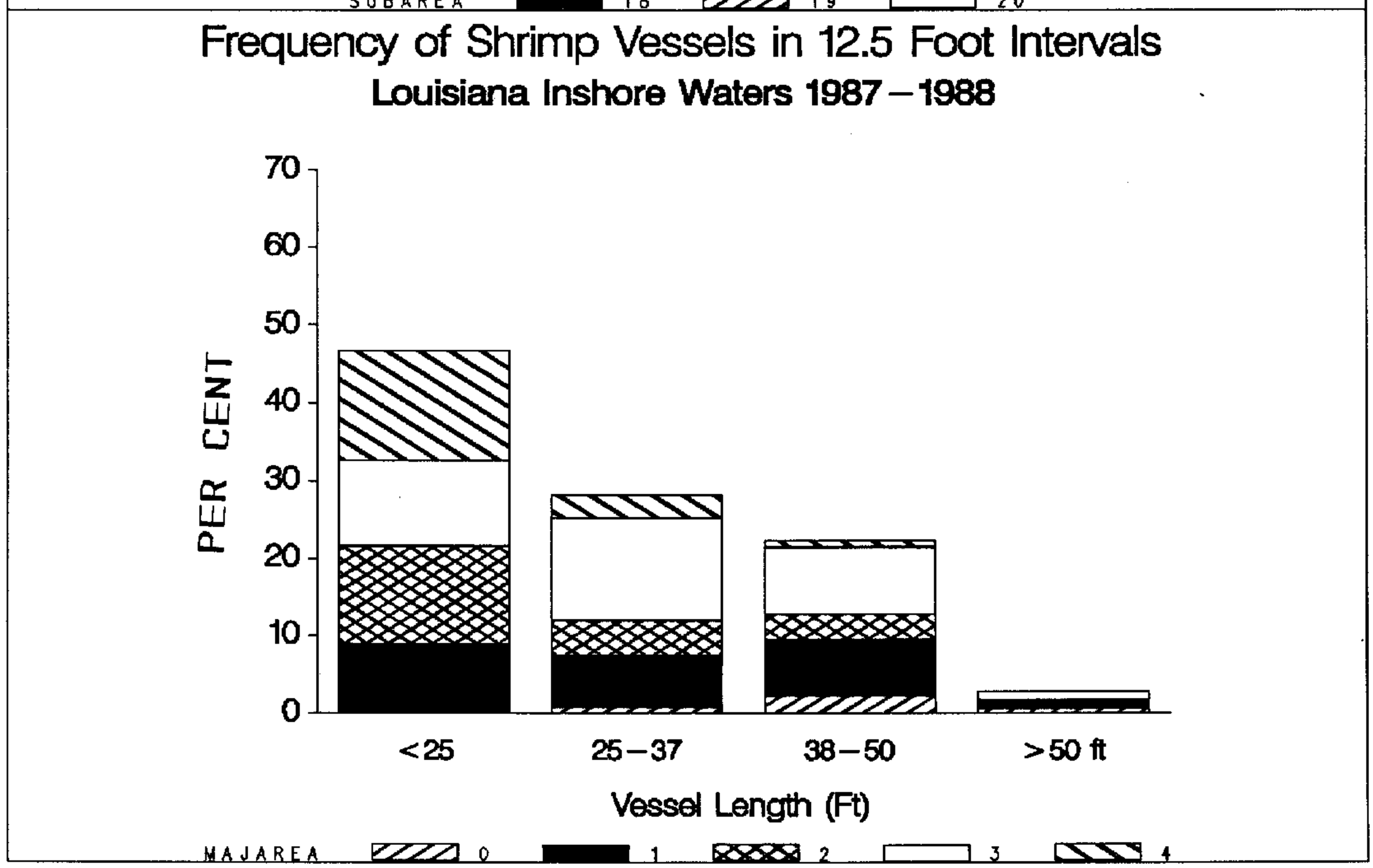
Frequency of Tow Durations by 30 Minute Intervals

Texas Areas 18-20 -- 1987-1988



F i g. 8


Frequency of Shrimp Vessels in 12.5 Foot Intervals
Texas Inshore Waters 1987–1988
PER CENT
70
60
50
40
30
20
10
0
<25
25–37
38–50
>50 ft
Vessel Length (Ft)
SUBAREA
18
19
20


Frequency of Shrimp Vessels in 12.5 Foot Intervals
Louisiana Inshore Waters 1987–1988
PER CENT
70
60
50
40
30
20
10
0
<25
25–37
38–50
>50 ft
Vessel Length (Ft)
MAJAREA
0
1
2
3
4

F I G. 9

Frequency of Shrimp Trawl Times Less Than 90 Minutes

North Carolina Ports – – Aug. – Oct. 1988

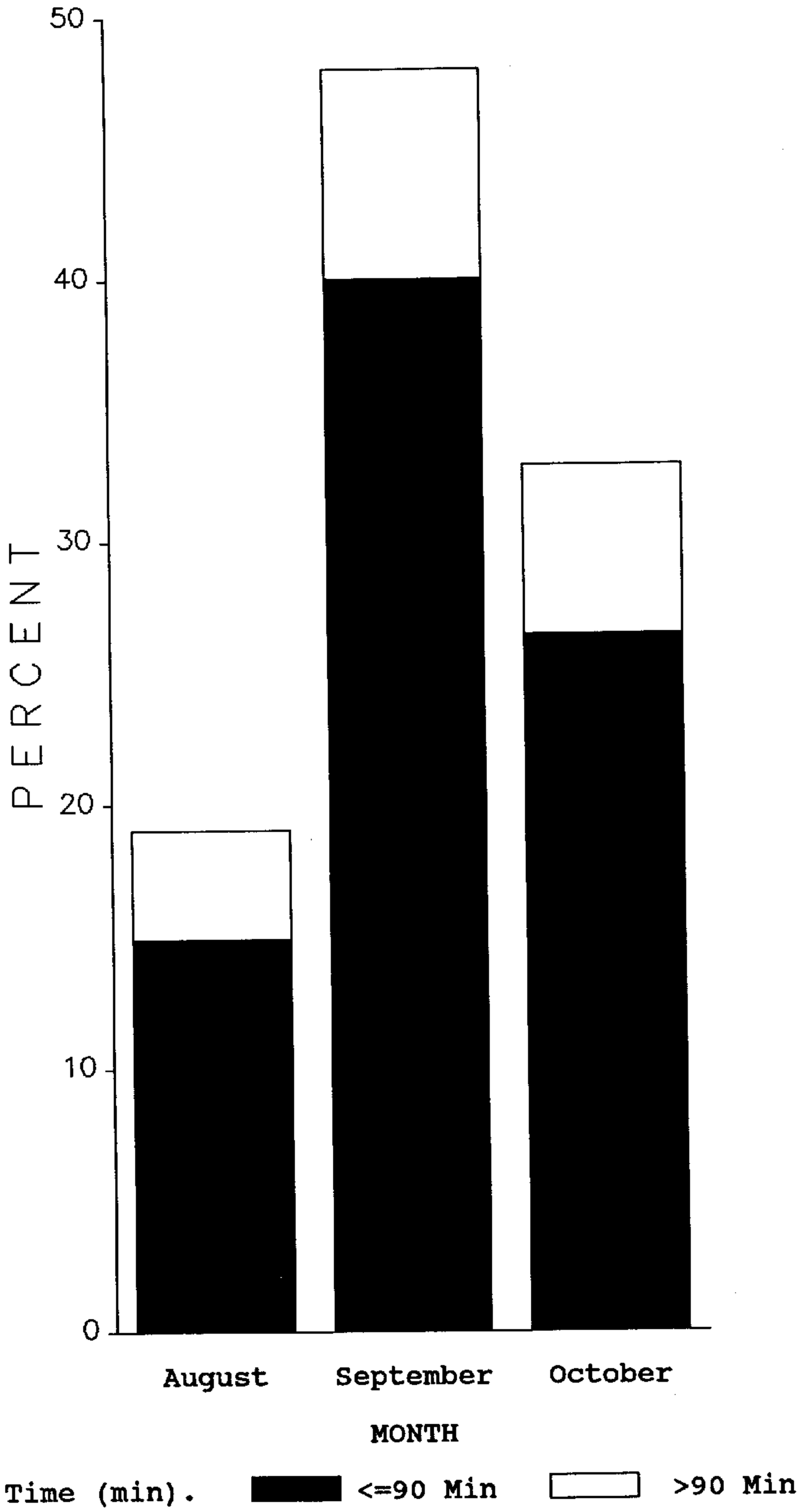


TABLE 1
Sampling Distribution and Mean Tow Duration by Year--Gear Combined
Gulf of Mexico Inshore Waters 1987-1988

YEAR		Total Tows
1987	No. Tows	8159
	Mean Time (min)	113.47
	St Dev	58.29
1988	No. Tows	5236
	Mean Time (min)	129.42
	St Dev	52.88
All	No. Tows	13395
	Mean Time (min)	119.71
	St Dev	56.77

TABLE 2

GLM --Tow Duration as a Function of Gear, Year, Subarea, Y*G, Y*S, S*G

Tow Duration Untransformed

Subareas 12-15 Only

Class Level Information

Class	Levels	Values
YEAR	2	87 88
SUBAREA	4	12 13 14 15
GEAR	2	Trawl Butterfly

Number of observations in data set = 7889

Dependent Variable: TOW TIME (MIN)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	12	6210311.315	517525.943	171.04	0.0
Error	7876	23830960.238	3025.769		
Corrected Total	7888	30041271.553			

R-Square	C.V.	Root MSE	TOW TIME (MIN) Mean
0.206726	47.09095	55.00699	116.810115

Source	DF	Type IV SS	Mean Square	F Value	Pr > F
YEAR	1	341918.015	341918.015	113.00	0.0001
SUBAREA	3	516759.034	172253.011	56.93	0.0001
GEAR	1	998633.270	998633.270	330.04	0.0001
YEAR*SUBAREA	3	21307.604	7102.535	2.35	0.0707
YEAR*GEAR	1	1060714.846	1060714.846	350.56	0.0001
SUBAREA*GEAR	3	325201.877	108400.626	35.83	0.0001

TABLE 3A
Sampling Distribution and Mean Duration of Trawls Only By Year
Gulf of Mexico Inshore Waters 1987-1988

		Trawl Duration				
		No.Trawls	MAX	MIN	MEAN	STD
YEAR	SUBAREA					
87	11	0	--	--	--	--
	12	86	300	60	165.70	56.50
	13	112	240	60	125.49	38.62
	14	4747	600	30	104.63	45.85
	15	124	240	60	134.03	30.71
	16	37	210	60	123.24	38.59
	17	26	180	20	105.77	38.07
	18	780	360	30	132.05	49.39
	19	1582	300	15	106.28	44.44
	20	457	360	10	116.89	43.69
	21	2	150	150	150.86	.00
All 1987	All Trawls	7951	600	10	109.86	46.84
88	SUBAREA					
	11	5	120	120	120.00	0.00
	12	34	180	120	142.94	26.69
	13	714	480	60	133.70	35.26
	14	1415	512	12	110.67	39.47
	15	50	180	120	144.00	29.69
	18	895	240	30	102.61	36.07
	19	1241	300	60	156.58	45.47
	20	480	240	60	130.75	43.27
All 1988	All Trawls	4836	512	12	126.94	45.11

TABLE 3A
Sampling Distribution and Mean Duration of Trawls
1987-1988 Combined

		Trawl Duration				
		No. Tows	MAX	MIN	MEAN	STD
Total Tows	SUBAREA					
	11	5	120	120	120.00	0.00
	12	120	300	60	159.25	50.83
	13	826	480	60	132.58	35.82
	14	6162	600	12	106.02	44.53
	15	174	240	60	136.90	30.67
	16	37	210	120	123.24	38.59
	17	26	180	20	105.77	38.07
	18	1675	360	30	116.32	45.23
	19	2823	300	15	128.39	51.37
	20	937	360	10	123.99	44.00
	21	2	150	150	150.71	0.00
All 1987-88	Total Tows	12787	600	10	116.32	46.93

TABLE 3B
Sampling Distribution and Mean Duration of Butterfly Sets by Year
Gulf of Mexico Inshore Waters 1987-1988

		Set Duration				
		No. Sets	MAX	MIN	MEAN	STD
YEAR	SUBAREA					
87	11	1	300	300	300.00	0.00
	12	4	300	180	225.00	57.45
	13	0	--	--	---	---
	14	192	720	30	245.62	173.05
	15	9	600	120	413.33	154.27
All 1987	Total Sets	206	720	30	252.82	173.45
88	SUBAREA					
	11	0	--	--	---	---
	12	10	120	120	120.00	0.00
	13	16	360	120	262.50	94.55
	14	376	560	60	155.90	104.43
	15	0	--	--	---	---
All 1988	Total Sets	402	560	60	159.25	104.91
1987+1988	SUBAREA					
	11	1	300	300	300.00	0.00
	12	14	300	120	150.00	56.43
	13	16	360	120	262.50	94.55
	14	568	720	30	186.23	138.22
	15	9	600	120	413.33	154.27
All 1987-88	Total Sets	608	720	30	190.95	139.27

TABLE 4

Frequency of Trawls Less Than or Greater Than 90 Minutes
Gulf of Mexico Inshore Waters 1987-1988

TIME	YEAR 87	YEAR 88	TOTAL BY TRAWL TIME	
<=90 MIN	3223	1254	4477	No. of Trawls
% All Trls	25.21	9.81	35.01	% All
% < 90	71.99	28.01		
% Year	40.53	25.94		
>90 MIN	4730	3580	8310	
% All Trls	36.99	28.00	64.99	
% >90	56.92	43.08		
% Year	59.47	74.06		
YEAR	7953	4834	12787	
% ALL	62.20	37.80	100.00	

TABLE 4A

Frequency of Tows Less Than or Greater Than 90 Minutes
Gulf of Mexico Inshore Waters 1987-1988

YEAR TOWTIME	87	88	TOTAL BY TOW TIME	
<=90 MIN	3275	1314	4589	No. of Tows
% All Tows	24.45	9.81	34.26	% All
% < 90	71.37	28.63		
% Year	40.14	25.10		
>90 MIN	4884	3922	8806	
% All Tows	36.46	29.28	65.74	
% >90	55.46	44.54		
% Year	59.86	74.90		
YEAR	8159	5236	13395	
% ALL	60.91	39.09	100.00	

TABLE 5
Sampling Distribution of Trawls by Statistical Subarea
Gulf of Mexico Inshore Waters 1987-1988

		YEAR		
		87	88	Total Trawls
Total Trawls	No. Trawls	7951	4834	12787
SUBAREA				
11	No. Trawls	0	5	5
	% Trawls	0	.10	0.04
12	No. Trawls	86	34	120
	% Trawls	1.08	0.70	0.94
13	No. Trawls	112	714	826
	% Trawls	1.41	14.77	6.46
14	No. Trawls	4747	1415	6162
	% Trawls	59.70	29.27	48.19
15	No. Trawls	124	50	174
	% Trawls	1.56	1.03	1.36
16	No. Trawls	37	0	37
	% Trawls	0.47	0.00	0.30
17	No. Trawls	26	0	26
	% Trawls	0.32	0.00	0.20
18	No. Trawls	780	895	1675
	% Trawls	9.80	18.51	13.10
19	No. Trawls	1582	1241	2823
	% Trawls	19.90	25.67	22.08
20	No. Trawls	457	480	937
	% Trawls	5.78	9.92	9.37
21	No. Trawls	2	0	2
	% Trawls	0.00	0.00	0.00
All Trawls	No. Trawls	7951	4834	12787
	% All Trawls	62.18	37.82	100.00

TABLE 6A

GLM --Tow Duration as Function of Gear, Year and Subarea
Areas 11, 16 , 17 and 21 Omitted

Class	Levels	Values
GEAR	2	butterfly trawl
YEAR	2	87 88
SUBAREA	7	12 13 14 15 18 19 20

Number of observations in data set = 13326

Dependent Variable: TOW DURATION

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	18	8690758.945	482819.941	187.04	0.0
Error	13307	34350442.950	2581.381		
Corrected Total	13325	43041201.895			

R-Square	C.V.	Root MSE	TOW DURATION
0.201917	42.44136	50.80730	119.71

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	1	497262.546	497262.546	192.63	0.0001
GEAR	1	998633.270	998633.270	386.86	0.0001
SUBAREA	6	728886.699	121481.117	47.06	0.0001
YEAR*GEAR	1	1060714.846	1060714.846	410.91	0.0001
YEAR*SUBAREA	6	1804568.741	300761.457	116.51	0.0001
SUBAREA*GEAR	3	325201.877	108400.626	41.99	0.0001

TABLE 6B

GLM--Trawls Only Year, Subarea and Interactions Y*S
General Linear Models Procedure
Class Level Information

Class	Levels	Values
YEAR	2	87 88
SUBAREA	7	12 13 14 15 18 19 20

Number of observations in data set = 12719

Dependent Variable: TOW DURATION

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	3861931.232	297071.633	155.92	0.0
Error	12705	24206168.191	1905.247		
Corrected Total	12718	28068099.424			

R-Square	C.V.	Root MSE	TOW DURATION
0.137591	37.52493	43.64914	116.32

Source	DF	Type IV SS	Mean Square	F Value	Pr > F
YEAR	1	14677.802	14677.802	7.70	0.0055
SUBAREA	6	1239924.588	206654.098	108.47	0.0001
YEAR*SUBAREA	6	1804373.595	300728.932	157.84	0.0001

TABLE 7 A
Sampling Distribution and Mean Tow Duration Trawls Only
Within Statistical Area 14 in 1987 and 1988

	YEAR				
	87		88		
	Tow Time		Tow Time		
AREA	No. Tows	Mean Time(min)	No. Tows	Mean Time(min)	Total Trawls
14	179	102.23	0	--	179
14.1	20	123.00	94	131.49	114
14.11	434	89.29	0	--	434
14.12	238	126.18	45	158.67	283
14.13	537	121.12	166	116.20	703
14.14	105	115.71	34	106.76	139
14.15	29	142.76	15	112.00	44
14.2	1	480.00	0	--	1
14.21	213	96.20	0	--	213
14.22	259	118.61	113	124.96	372
14.23	332	103.19	271	97.12	603
14.24	54	113.33	20	117.00	74
14.25	32	69.38	41	93.66	73
14.31	538	80.33	0	--	538
14.32	305	88.38	7	120.00	312
14.33	43	124.19	19	123.16	62
14.34	440	125.80	258	133.14	698
14.35	183	121.64	44	88.64	227
14.36	67	142.39	41	111.95	108
14.37	135	101.78	10	102.00	145
14.38	58	95.17	4	120.00	62
14.39	6	120.00	0	--	6
14.41	293	88.87	124	66.77	417
14.42	188	94.95	109	92.48	297
14.43	19	69.47	0	--	19
14.44	39	93.85	0	--	39

TABLE 7 B
Sampling Distribution and Mean Tow Duration -Butterfly Sets
Within Statistical Area 14 in 1987 and 1988

	YEAR				Total
	87		88		
	Tow Time		Tow Time		
	No. Sets	Mean Time(min)	No. Sets	Mean Time(min)	No. Sets
AREA 14.1	0	--	15	152.00	15
14.12	8	105.00	0	--	8
14.13	8	225.00	0	--	8
14.14	1	720.00	0	--	1
14.22	5	180.00	0	--	5
14.23	6	210.00	6	140.00	12
14.24	1	480.00	0	--	1
14.25	8	90.00	0	--	8
14.32	1	420.00	0	--	1
14.34	27	140.00	167	143.11	194
14.35	19	227.37	9	113.33	28
14.36	18	340.00	0	--	18
14.37	11	327.27	0	--	11
14.38	21	260.00	0	--	21
14.41	29	281.46	144	181.94	173
14.42	14	381.42	35	125.14	49
14.43	1	300.00	0	--	1
14.44	14	210.00	0	--	14
Total	192	.00	376	--	568

TABLE 8
Frequency of Tows Less than 90 Minutes
By Subdivisions of Area 14 1987-1988

	YEAR				ALL
	87		88		
	Tow Time (min)		Tow Time (min)		Tow Time (min)
	<= 90 min	>90 min	<= 90 min	>90 min	<= 90 min
	No. Tows	No. Tows	No. Tows	No. Tows	No. Tows
AREA					
14	72	101	0	0	72
14.1	365	634	14	95	379
14.11	258	141	0	0	258
14.12	26	210	0	45	26
14.13	90	361	36	130	126
14.14	29	56	11	23	40
14.15	6	14	4	11	10
14.2	0	1	0	0	0
14.21	105	92	0	0	105
14.22	44	124	23	90	67
14.23	93	107	152	125	245
14.24	22	32	2	18	24
14.25	37	0	24	17	61
14.31	418	121	0	0	418
14.32	175	97	0	7	175
14.33	6	33	4	15	10
14.34	92	286	56	369	148
14.35	61	73	25	28	86
14.36	11	55	8	33	19
14.37	41	81	3	7	44
14.38	29	35	0	4	29
14.41	150	39	141	127	291
14.42	82	57	74	70	156
14.43	7	1	0	0	7
14.44	22	26	0	0	22

TABLE 9A
Tow Duration as Function of Major Area, Year, Gear and Interactions

General Linear Models Procedure

Class	Levels	Values
YEAR	2	87 88
AREA	5	14 14.1 14.2 14.3 14.4
GEAR	2	Trawl Butterfly

Number of observations in data set = 6730

Dependent Variable: Tow Duration

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	4919360.389	819893.398	256.62	0.0001
Error	6723	21479871.498	3194.983		
Corrected Total	6729	26399231.887			

R-Square	C.V.	Root MSE	Mean Tow Duration
0.1863	50.1163	56.5242	112.79

Source	DF	Type III SS	Mean Square	F Value	Pr > F
TOWTYPE	1	1347.470	1347.470	0.42	0.5161
YEAR	1	100799.596	100799.596	31.55	0.0001
MAJAREA	1	105583.268	105583.268	33.05	0.0001
YEAR*TOWTYPE	1	1031444.064	1031444.064	322.83	0.0001
MAJAREA*YEAR	1	49808.001	49808.001	15.59	0.0001
MAJAREA*TOWTYPE	1	349127.128	349127.128	109.27	0.0001

TABLE 9B
Trawl Duration as Function of Year and Major Area
Area 14

Class	Levels	Values
YEAR	2	87 88
AREA	5	14 14.1 14.2 14.3 14.4

Number of observations in data set = 6162

Dependent Variable: Trawl Duration

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	614757.6248	76844.7031	40.74	0.0001
Error	6153	11605502.8166	1886.1536		
Corrected Total	6161	12220260.4414			

R-Square	C.V.	Root MSE	Mean Trawl Duration
0.050306	40.96543	43.42987	106.02

TABLE 10
Number of Tows by Year, Month and Statistical Area
Louisiana and Texas Inshore Waters 1987-1988

	Total Tows
	No. Tows
YEAR	
87	8614
88	5236
Total Tows	13850
MONTH	
MAY	13
JUNE	3978
JULY	2410
AUGUST	3510
SEPTEMBER	3100
OCTOBER	839
Total Tows	13850

TABLE 11
Frequency of Tows Less than 90 Minutes by Month
Louisiana and Texas Inshore Waters 1987-1988

MONTH

	MAY	JUNE	JULY	AUGUST	SEPT	OCT	Total
<=90 MIN	6	1701	751	1128	874	155	4615
% Total	0.04	12.28	5.42	8.14	6.31	1.12	33.32
% All<=90	0.13	36.86	16.27	24.44	18.94	3.36	
% by Mon	46.15	42.76	31.16	32.14	28.19	18.47	
> 90 MIN	7	2277	1659	2382	2226	684	9235
% Total	0.05	16.44	11.98	17.20	16.07	4.94	66.68
% All>90	0.08	24.66	17.96	25.79	24.10	7.41	
% by Mon	53.85	57.24	68.84	67.86	71.81	81.53	
Total	13	3978	2410	3510	3100	839	13850
	0.09	28.72	17.40	25.34	22.38	6.06	100.00

TABLE 12 A
Frequency of Vessels by 12.5 ft Intervals
Texas Inshore Waters 1987-1988

Vessel Length (Ft) / Frequency / Percent / Row Pct / Col Pct	Statistical Areas 18	19	20	Total
<=25 ft	10	11	4	25
	0.46	0.51	0.18	1.15
	40.00	44.00	16.00	
	1.41	1.20	0.74	
26 thru 37	220	398	197	815
	10.15	18.37	9.09	37.61
	26.99	48.83	24.17	
	31.12	43.36	36.35	
38-50 ft	463	499	339	1301
	21.37	23.03	15.64	60.04
	35.59	38.36	26.06	
	65.49	54.36	62.55	
>50 ft	14	10	2	26
	0.65	0.46	0.09	1.20
	53.85	38.46	7.69	
	1.98	1.09	0.37	
Total	707	918	542	2167
	32.63	42.36	25.01	100.00

TABLE 12 B
Frequency of Vessels by 12.5 ft Intervals
Louisiana Inshore Waters 1987-1988

VESSEL LENGTH (FT) Frequency / Percent / Row Pct / Col Pct	SUBDIVISONS OF AREA 14					
	0	1	2	3	4	Total
<=25 ft	1	135	193	167	213	709
	0.07	8.89	12.71	11.00	14.03	46.71
	0.14	19.04	27.22	23.55	30.04	
	1.79	37.29	62.06	32.18	78.89	
26 thru 37	12	103	67	201	45	428
	0.79	6.79	4.41	13.24	2.96	28.19
	2.80	24.07	15.65	46.96	10.51	
	21.43	28.45	21.54	38.73	16.67	
38-50 ft	34	110	49	133	12	338
	2.24	7.25	3.23	8.76	0.79	22.27
	10.06	32.54	14.50	39.35	3.55	
	60.71	30.39	15.76	25.63	4.44	
>50 ft	9	14	2	18	0	43
	0.59	0.92	0.13	1.19	0.00	2.83
	20.93	32.56	4.65	41.86	0.00	
	16.07	3.87	0.64	3.47	0.00	
Total	56	362	311	519	270	1518
	3.69	23.85	20.49	34.19	17.79	100.00

TABLE 14
Frequency of Shrimp Tows Less
Than 90 Minutes--Aug.-Oct. 1988

Tow Time (min)			
<= 90 min		>90 min	
Number	Percent	Number	Percent
252	81.3	58	18.7

APPENDIX
Table 1
Mean Tow Duration by Year, Month and Statistical Area
Louisiana and Texas Inshore Waters 1987-1988

	SUBAREA				
	11			12	
	TOW DURATION			TOW DURATION	
	No. Tows	Mean Towtime (min)	Std. Dev.	No. Tows	Mean Towtime (min)
YEAR					
87	1	300.00	0.00	88	168.07
88	5	120.00	0.00	44	137.73
Total Tows	6	150.00	73.48	132	157.95
MONTH					
MAY	0	--	--	--	--
JUNE	0	--	--	20	120.00
JULY	1	300.00	--	21	212.86
AUGUST	5	120.00	0.00	60	158.00
SEPTEMBER	0	--	--	7	120.00
OCTOBER	0	--	--	24	152.50
Total Tows	6	150.00	73.48	132	157.95

APPENDIX
Table 1 (Cont. 1)
Mean Tow Duration by Year, Month and Statistical Area
Louisiana and Texas Inshore Waters 1987-1988

	SUBAREA				
	12	13			14
	TOW DURATION	TOW DURATION			TOW DURATION
	Std. Dev.	No. Tows	Mean Towtime (min)	Std. Dev.	No. Tows
YEAR					
87	58.17	112	125.49	38.62	5018
88	25.32	730	136.52	41.91	1791.00
Total Tows	51.61	842	135.05	41.63	6809.00
MONTH					
MAY	0	--	--	--	--
JUNE	0	91	138.30	63.67	2120.00
JULY	44.40	243	145.68	35.56	689.00
AUGUST	56.83	161	134.35	51.40	1985.00
SEPTEMBER	0.00	269	127.81	31.41	1745.00
OCTOBER	26.42	78	124.62	25.16	270.00
Total Tows	51.61	842	135.05	41.63	6809.00

APPENDIX
Table 1 (Cont. 3)
Mean Tow Duration by Year, Month and Statistical Area
Louisiana and Texas Inshore Waters 1987-1988

	SUBAREA				
	16			17	
	TOW DURATION			TOW DURATION	
	No. Tows	Mean Towtime (min)	Std. Dev.	No. Tows	Mean Towtime (min)
YEAR					
87	4	120.00	0.00	10	30.00
88	--	--	--	--	--
Total Tows	4	120.00	0.00	10	30.00
MONTH					
MAY	--	--	--	--	--
JUNE	4	120.00	0.00	--	--
JULY	--	--	--	10.00	30.00
AUGUST	--	--	--	--	--
SEPTEMBER	--	--	--	--	--
OCTOBER	--	--	--	--	--
Total Tows	4	120.00	0.00	10	30.00

APPENDIX
Table 1 (cont.4)
Mean Tow Duration by Year, Month and Statistical Area
Louisiana and Texas Inshore Waters 1987-1988

	SUBAREA				
	17	18			19
	TOW DURATION	TOW DURATION			TOW DURATION
	Std. Dev.	No. Tows	Mean Towtime (min)	Std. Dev.	No. Tows
YEAR					
87	0.00	796	132.05	49.55	1642
88	--	895	102.61	36.07	1241
Total Tows	0.00	1691	116.47	45.38	2883
MONTH					
MAY	--	13	103.85	19.81	--
JUNE	--	392	100.14	30.58	578
JULY	0.00	288	98.68	39.36	805
AUGUST	--	516	118.97	47.22	642
SEPTEMBER	--	334	145.64	51.01	665
OCTOBER	--	148	120.91	33.27	193
Total Tows	0.00	1691	116.47	45.38	2883

APPENDIX
Table 1 (Cont. 5)
Mean Tow Duration by Year, Month and Statistical Area
Louisiana and Texas Inshore Waters 1987-1988

	SUBAREA				
	19		20		
	TOW DURATION		TOW DURATION		
	Mean Towtime (min)	Std. Dev.	No. Tows	Mean Towtime (min)	Std. Dev.
YEAR					
87	106.33	43.02	872	133.14	42.69
88	156.58	45.47	480	130.75	43.27
Total Tows	127.96	50.62	1352	132.29	42.90
MONTH					
MAY	--	--	--	--	--
JUNE	126.41	47.64	753	127.77	42.79
JULY	124.80	62.91	313	134.86	40.20
AUGUST	125.62	47.37	110	150.00	58.18
SEPTEMBER	128.96	40.20	80	141.75	33.40
OCTOBER	150.10	37.72	96	131.25	30.55
Total Tows	127.96	50.62	1352	132.29	42.90

APPENDIX
Table 2
Sampling Distribution and Mean Tow Duration Gear Combined
1987-1988 Combined

		Tow Duration				
		No. Tows	MAX	MIN	MEAN	STD
Total Tows	SUBAREA					
	11	6	300	120	150.00	73.48
	12	134	300	60	158.28	51.29
	13	842	480	60	135.05	41.63
	14	6730	720	12	112.78	62.64
	15	183	600	60	150.49	74.39
	16	37	210	120	123.24	38.59
	17	26	180	20	105.77	38.07
	18	1675	360	30	116.32	45.23
	19	2823	300	15	128.39	51.37
	20	937	360	10	123.99	44.00
	21	2	150	150	150.00	0.00
All 1987-88	Total Tows	13395	720	10	119.71	56.77