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OBSERVATIONS OF SEA TURTLES AND OTHER MARINE LIFE AT THE EXPLOSIVE REMOVAL OF OFFSHORE OIL AND GAS STRUCTURES IN THE GULF OF MEXICO

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ABSTRACT Observers monitored the explosive removal of oil and gas structures in the Gulf of Mexico to protect sea turtles and marine mammals from adverse impacts. More than 7,000 monitoring hours at 131 structure removals were conducted during 1993. Sixteen individual sea turtles were observed including 6 loggerheads, 1 Kemp's ridley, 1 green, and 8 unidentified sea turtles. Aerial surveys were approximately ten times more effective in observing sea turtles than day or night surface surveys.

Introduction

During the summer of 1993 oil and gas production platforms in the Gulf of Mexico totaled nearly 4,000. This number did not include hundreds of smaller, non-producing structures such as well jackets and caissons. Nearly all of these are located in waters off the Louisiana and Texas coasts. Owners are required by federal regulations to remove these structures within one year after lease termination.[1] The most economical removal method utilizes underwater explosives which can have a negative impact on local marine life. During the past four years, explosive structure removals averaged more than 120 annually.

Sea turtles are known to frequent reefs and other areas with submerged structures (Stoneburner 1982; Carr 1954; Booth and Peters 1972; Witzell 1982). Consequently, it is not surprising to find sea turtles at oil and gas structures (Gitschlag and Renaud 1989; Gitschlag and Herczeg 1994; Gitschlag and Hale[2]) which are themselves artificial reefs. Although all five species of sea turtles inhabiting the western Gulf of Mexico are listed as either threatened or endangered, attention to the effects of platform salvage did not occur until 1986. In the spring of that year, 51 sea turtles and 41 bottlenose dolphin (*Tursiops truncatus*) washed up dead on north Texas beaches coincidental with the explosive removal of structures just a few miles offshore (Klima et al 1988). This resulted in a formal consultation authorized under the Endangered Species Act between the National Marine Fisheries Service (NMFS) and Minerals Management Service (MMS), the agencies with jurisdiction in federal waters. One consequence of the consultation was a procedure requiring oil and gas companies to obtain a permit from MMS prior to using explosives in federal waters. An Incidental Take Statement accompanying the formal consultation prepared by NMFS was included in the permit and described requirements to protect sea turtles (Table 1). Among these requirements was the use of personnel trained to monitor for sea turtles. Similar procedures were established for structure removals in state waters where permits were obtained from the U.S. Army Corps of Engineers (COE).

Mandatory use of trained observers began in 1987. This article summarizes the 1993 findings of the NMFS monitoring program at explosive structure removals in the Gulf of Mexico plus two additional platforms which were originally scheduled for explosives but were actually removed using mechanical techniques.

Materials and Methods

Surveys were conducted from helicopters (aerial surveys) as well as from vessels and oil and gas platforms (surface surveys). The area within a 1600 m radius of the removal site was monitored during 30 min pre- and post-detonation aerial surveys at altitudes of 150-200 m, speeds of 100-150 kph, and only during daylight hours. Surface surveys usually began at least 48 hours prior to detonation of explosives and were typically conducted from a vessel positioned immediately adjacent to the structure being salvaged. Surface surveys were occasionally performed at

[1] Oil, Gas and Sulfur Operations in the Outer Continental Shelf, 30 CFR (250 series).

[2] Gitschlag, G.R. and J.K. Hale. Susceptibility of Sea turtles to underwater explosives at offshore energy structure removals. Unpubl. manuscr. on file at NMFS Galveston Laboratory, SEFSC, Galveston, TX 77551.

TABLE 1

Summary of "Generic" Incidental Take Statement

1. Qualified observers monitor for sea turtles beginning 48 hours prior to detonations.
2. Thirty minute aerial surveys within one hour prior to and after detonation.
3. If sea turtles are observed within 1000 yards of the structure, and detonations and repeat aerial survey.
4. No detonations will occur at night.
5. During salvage-related diving, divers must report turtle and dolphin sightings. If turtles are thought to be resident, pre- and post-detonation diver surveys must be conducted.
6. Explosive charges must be staggered to minimize cumulative effects of the explosions.
7. Avoid use of "scare" charges to frighten away turtles which may actually be attracted to feed on dead marine life and subsequently exposed to explosions.
8. Removal company must file a report summarizing the results.

neighboring structures and, when aerial surveys were waived due to adverse weather conditions, aboard vessels cruising a search pattern within 1,000 m of the structure. Binoculars were used to increase visual acuity when necessary. Estimates of the number of dead, floating fish were made after each detonation and a sample was collected whenever possible. Commercial divers conducted underwater surveys at some structures.

Terminology and data analysis

Certain terminology used in this report requires definition. A sea turtle "sighting" was recorded whenever a sea turtle was observed. If one sea turtle was seen on two separate occasions or if two sea turtles were seen simultaneously, two sightings were recorded. Each sea turtle was counted as a unique "individual" unless there was evidence, for example, barnacle pattern or carapace size, indicating that the same individual appeared repeatedly. Since the occurrence of repetitive sightings could not always be determined, the number of individual sea turtles described in this report represents an upper limit of the actual number observed.

The distinction was made between sightings of sea turtles by trained NMFS personnel and non-NMFS personnel. Unless otherwise noted, results refer to NMFS data. Sea turtles sighted by trained NMFS employees were recorded as NMFS sightings. Observation "rates" were determined by dividing the number of individual sea turtles by the number of monitoring hours. However, observation rates calculated by time of day used frequencies of sea turtle sightings, not of individual sea turtles, to determine surface activity patterns. All rates refer to NMFS data because monitoring effort was not recorded for non-NMFS personnel.

Visual surveys were cataloged as day, night, and aerial surveys. Day and night surveys were conducted from vessels and platforms and collectively were referred to as surface surveys. Aerial surveys were performed from helicopters. Effort for surface surveys was based on man-hours of monitoring while effort for aerial surveys was based on flight hours regardless of the number of people in the helicopter.

Structures were classified as platforms, caissons, submerged casing stubs, and flare piles. Platforms were defined as multi-pile structures while caissons had only a single pile penetrating the sea floor. Casing stubs were submerged, single pile, well conductors or caissons rising from the sea floor but not reaching the water's surface. Flare piles were defined as single pile structures which supported a flare vent and were located at least 200 m from the nearest platform.

The chi-square test was used to determine differences between test parameters. Categories within test parameters were often pooled to provide acceptable sample sizes since sea turtle sightings occurred infrequently. To facilitate analysis, the study area was divided into five regions: western Louisiana, central Louisiana, eastern Louisiana, north Texas and south Texas (Figure 1).

RESULTS

Overview

One hundred thirty-one offshore structure removals were monitored including 92 platforms, 35 caissons, 2 casing stubs, and 2 flare piles (Table 2). Most removals occurred in relatively shallow water. Twenty-seven percent were in water depths of 15 m or less, 42% in 15-30 m, 26% in 30-60 m, and 5% in greater depths. Sixty percent of platform removals, 91% of caissons, both flare piles, and one of three casing stub removals occurred in water depths less than or equal to 30 m. The deepest removal was a platform in 104 m of water.

Structure removals were monitored across the northwestern Gulf of Mexico from the Louisiana delta to South Padre Island, Texas. Approximately 85% of monitored removals occurred in central and western Louisiana waters between Grand Isle in the east and the

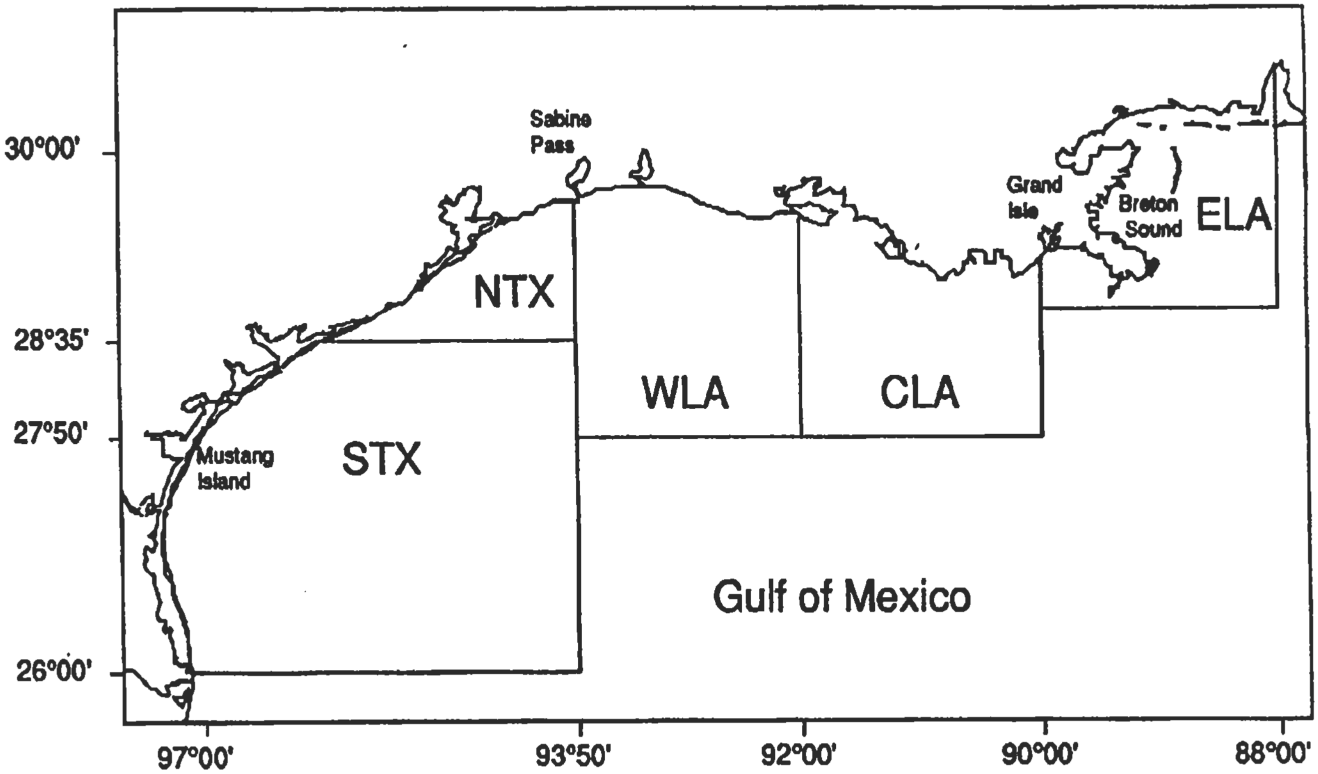


Figure 1. Partitioning of study area into five regional geographic areas (ELA=eastern Louisiana, CLA=central Louisiana, WLA=western Louisiana, NTX=north Texas, STX=south Texas).

Sabine River in the west, while 10% were in eastern Louisiana and 5% in south Texas. No explosive structure removals were reported in north Texas waters.

Energy and salvage companies usually scheduled removals during summer and fall to minimize costs caused by weather delays. Eighty-seven percent of explosive structure removals occurred from June through December.

Monitoring effort

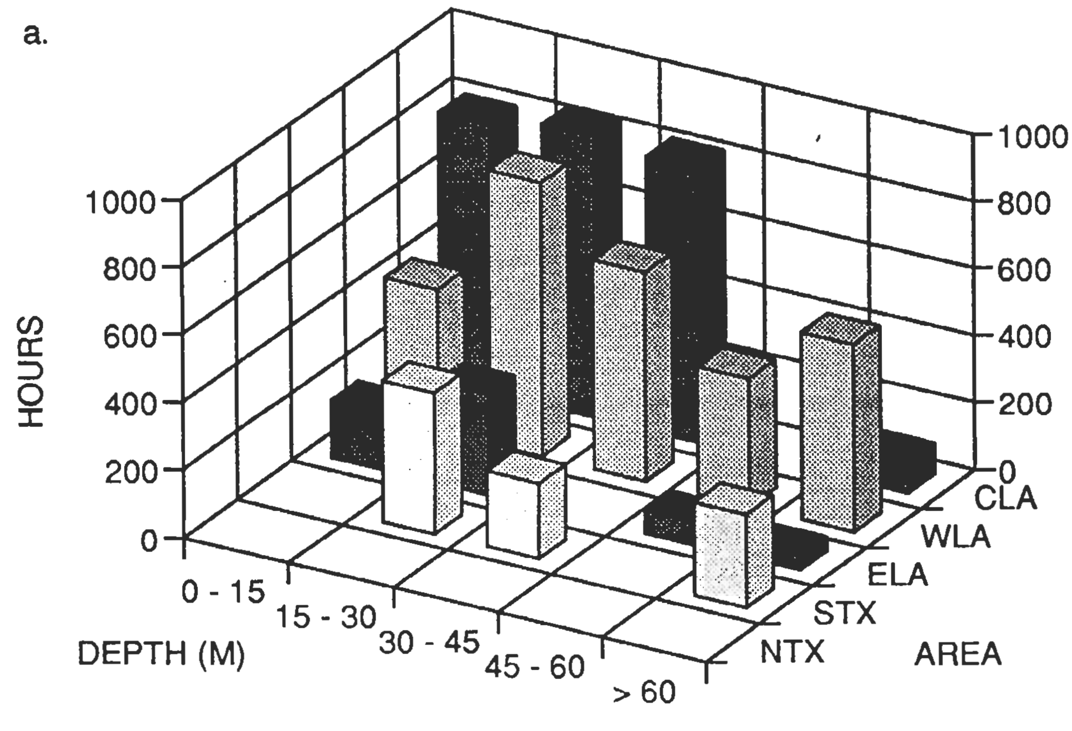
Monitoring effort included 4,009, 2,799, and 220 hours for day, night, and aerial surveys, respectively, for a total of 7,028 hours. Values were highest in central and western Louisiana and in the 15-30 m depth zone (Figure 2a & b).

TABLE 2

Frequency of monitored removals by structure type and water depth.

Water depth (m)	Platform	Caisson	Casing stub	Flare pile	Total	%
≤15	15	20	0	0	35	27
15-30	40	12	1	2	55	42
30-60	30	3	1	0	34	26
60-90	5	0	0	0	5	4
90-120	2	0	0	0	2	1
Total	92	35	2	2	131	

a.



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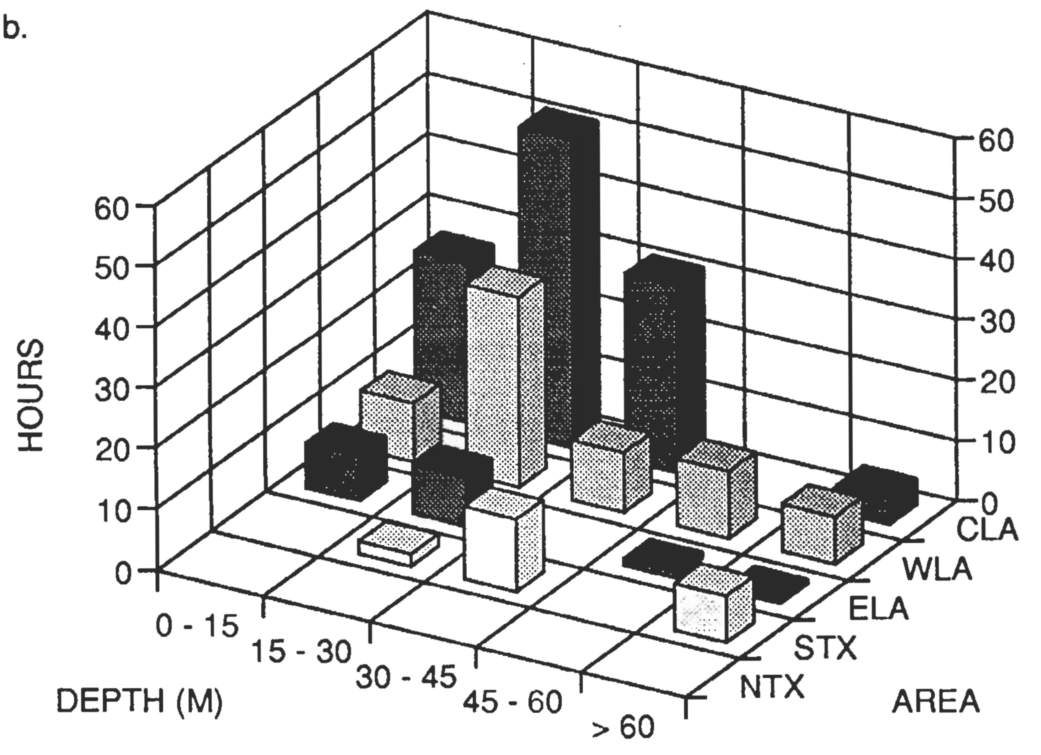


Figure 2. a. Surface monitoring effort by depth and geographic area (NTX=north Texas, STX=south Texas, ELA=eastern Louisiana, WLA=western Louisiana, CLA=central Louisiana), and b. Aerial monitoring effort by depth and geographic area (NTX=north Texas, STX=south Texas, ELA=eastern Louisiana, WLA=western Louisiana, CLA=central Louisiana).

Species

Thirty-six sightings of 16 individual sea turtles were made by NMFS personnel. Included were 6 loggerhead (*Caretta caretta*), 1 Kemp's ridley (*Lepidochelys kempii*), 1 green (*Chelonia mydas*), and 8 unidentified sea turtles (Table 3). Additional sightings by non-NMFS personnel increased these values to 47 sightings of 22 individual sea turtles.

TABLE 3

Frequency of sea turtle sightings and individuals. Observations from both NMFS and non-NMFS personnel are included in the "Total" columns.

	Sightings		Individuals	
Species	NMFS	Total	NMFS	Total
Loggerhead	26	30	6	6
Green	1	1	1	1
Kemp's	1	1	1	1
Unknown	8	15	8	14
Total	36	47	16	22

Survey method

Encounters with sea turtles varied by survey method. Sea turtle observation rates for day, night, and aerial surveys were dissimilar (0.0032, 0.0004, 0.0182 individuals per hour, respectively, Table 4). Twenty-eight sightings of 13 individual sea turtles were recorded during day surveys, 2 sightings of 1 individual during night surveys, and 6 sightings of 4 individuals during aerial surveys. When the frequency of sea turtles was adjusted for variations in monitoring effort and analyzed statistically, results showed significant differences between all categories ($P<0.0005$, Table 5). Comparison of sea turtle observation rates for aerial and surface surveys (day and night combined) showed the aerial survey rate was ten times higher. No sea turtles were observed during diver surveys conducted at 22 structure removal sites despite reported observations of turtles at 19 of these locations.

Structure type

More sea turtles were seen at platforms than at any other structure type. Thirty-one sightings of 15 individual sea turtles occurred at platform removals and 5 sightings of 1 individual at caisson removals (Table 6). An additional 9 sightings at platform removals and 2 sightings at caisson removals were reported by non-NMFS personnel. Although observation rates for surface surveys were approximately 2.5 times higher at platforms than at caissons (0.0022 and 0.0009), rates for aerial surveys were similar (0.0187 and 0.0180). The number of individual sea turtles reported by NMFS personnel per structure removal was 0.16 at platforms and 0.03 at caissons. NMFS observers recorded sea turtle sightings at 8% of the structures monitored while non-NMFS personnel reported sightings at an additional 3% of structures monitored. The occurrence of multiple structure removals at a single location (e.g. separate platforms connected by walkways) served to lower the apparent frequency with which turtles were encountered during surveys. To avoid this artifact, the percentage of monitored lease blocks (measuring approximately 16 sq km each as they appear on MMS lease charts) where turtles were observed was also calculated. NMFS personnel reported turtles at 10% of monitored blocks and this value increased to 16% when non-NMFS sightings were included. Two or more individual sea turtles were observed at three platforms, one each in south Texas, central Louisiana, and eastern Louisiana in water depths ranging from 25-38 m.

Water depth

Thirty of 36 total NMFS sightings occurred in water depths ranging from 15-60 m. This represented 14 of 16 (88%) individuals (Table 7). Sea turtle observation rates for surface surveys were highest for 15-30 m depths (0.0030) while rates for aerial surveys were highest for 0-15 m depths (0.0231, Figure 3 a & b). For depths greater than 60 m the sea turtle observation rate for surface surveys was 0.0012 compared with an aerial rate of zero.

Monthly observations

Sea turtles were reported from surface surveys only during the months of May, August, September, October, and December. Monthly observation rates ranged from 0.0008-0.0054 with the lowest value in September and the highest in October (Table 8). The absence of sea turtle sightings during the remaining months did not always correspond with low monitoring effort and few structure removals.

Aerial surveys sighted turtles during June, August, September and October when observation rates were 0.2762, 0.0287, 0.0153, and 0.0627, respectively.

TABLE 4

Frequency of sea turtle sightings and individuals, monitoring hours, and sea turtle observation rate by structure type. Observations from both NMFS and non-NMFS personnel are included in the "Total"column.

	Platform	Caisson	Casing stub	Flare pile	Total
Sightings					
NMFS	31	5	0	0	36
Total	40	7	0	0	47
Individuals					
NMFS	15	1	0	0	16
Total	20	2	0	0	22
Monitoring hours					
Day	3,319	617	47	26	4,009
Night	2,255	527	12	5	2,799
Aerial	160	55	3	2	220
Observation rate (individuals/hr)x 10^3					
Day	3.6	1.6	0	0	3.2
Night	0.4	0	0	0	0.4
Day & Night	2.2	0.9	0	0	1.9
Aerial	18.7	18.0	0	0	18.2

TABLE 5

Summary of chi-square analysis. The frequency of individual sea turtles was used in all cases except for time of day where sea turtle sightings were used. Expected values were adjusted for variations in monitoring effort in each category.

Parameters tested	Data Analyzed	N	P	Significant
Day, night, & aerial surveys	All structures	18	<0.0005	*
	Platforms	16	<0.0005	*
Day & night surveys	All Structures	14	<0.0005	*
Depth (0-30, 30-90m)	Day & night surveys	13	<0.7	
Time of day (6 x 4 hr periods)	Day & night surveys	30	<0.005	*

TABLE 6

Frequency of turtle sightings, individuals and structure removals by structure type. Observations from both NMFS and non-NMFS personnel are combined in the "Total" columns.

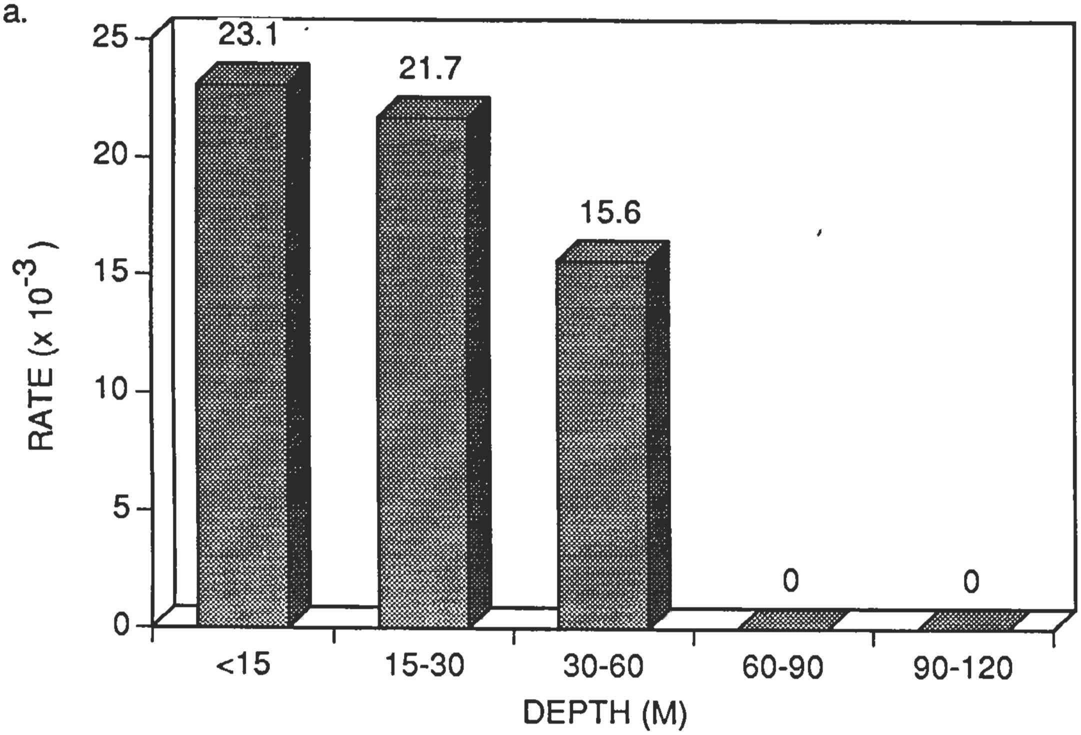
Structure type	Number of structures removed	Sightings		Individuals		Rate x 10^{-3}		
		NMFS	Total	NMFS	Total	Day	Night	Aerial
Platform	91	31	40	15	20	3.6	0.4	19.0
Caisson	36	5	7	1	2	1.6	0	17.4
Casing stub	2	0	0	0	0	0	0	0
Flare pile	2	0	0	0	0	0	0	0
Total	131	36	47	16	22			

TABLE 7

Frequency of NMFS sea turtle sightings and individuals by depth and structure type. A dash indicates no monitoring was conducted.

	Platform		Caisson		Casing Stub		Flare pile		Total	
Depth(m)	Sightings	Individuals	Sightings	Individuals	Sightings	Individuals	Sightings	Individuals	Sightings	Individuals
0-15	0	0	5	1	-	-	-	-	5	1
15-30	25	9	0	0	0	0	0	0	25	9
30-60	5	5	0	0	0	0	-	-	5	5
60-90	1	1	-	-	-	-	-	-	1	1
90-122	0	0	-	-	-	-	-	-	0	0
Total	31	15	5	1	0	0	0	0	36	16

a.



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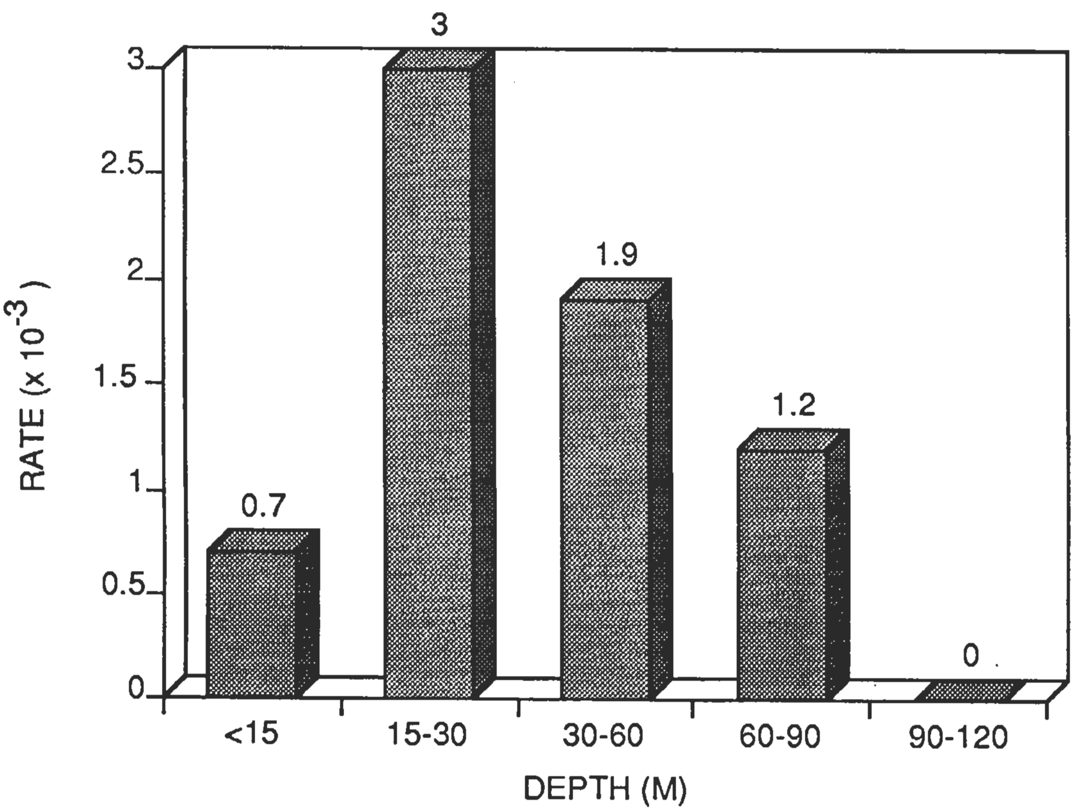


Figure 3. a. Aerial observation rates (individual sea turtles per hour x 10^{-3}) by depth zone, and b. Surface observation rates (individual sea turtles per hour x 10^{-3}) by depth zone.

TABLE 8

Surface and aerial monitoring effort, number of individual sea turtles observed, and observation rate (individuals per hour x 10^{-3}) by month.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Surface monitoring hours	405	161	148	161	522	291	999	1,135	1,213	744	635	394
# of individual sea turtles	0	0	0	0	2	0	0	4	1	4	0	2
Rate x 10^{-3}	0.0	0.0	0.0	0.0	3.8	0.0	0.0	3.5	0.8	5.4	0.0	5.1
Aerial monitoring hours	11	10	7	5	10	4	31	35	65	16	19	7
# of individual sea turtles	0	0	0	0	0	1	0	1	1	1	0	0
Rate x 10^{-3}	0.0	0.0	0.0	0.0	0.0	276.2	0.0	28.7	15.3	62.7	0.0	0.0

Monitoring effort for months with and without sea turtle sightings was generally comparable (Table 8).

Geographic area

No monitoring was conducted in north Texas. Sea turtle observation rates for surface surveys ranged from 0.0004 in western Louisiana to 0.0069 in eastern Louisiana (Table 9). Sea turtles were reported during aerial surveys only in Louisiana waters. Observation rates for aerial surveys were 0.1158, 0.0144, and 0.0089 for eastern, western, and central Louisiana, respectively.

Proximity to structures

Estimates of the proximity of sea turtles to the structure removal site are summarized by survey method (Table 10). Aerial surveys generally provided sightings at greater distances than surface surveys. Fifty-seven percent of sea turtles observed during surface surveys were within approximately 90 meters of the structure compared with 20% during aerial surveys.

Observations by time of day

Surface observation rates for sea turtle sightings were calculated for sequential four-hour time periods of the 24 hour day beginning at midnight. Lower rates generally occurred at night and higher rates during the day (Figure 4a).

TABLE 9

Observation rate (individual sea turtles per hour x 10^{-3}) by geographic area (ELA = eastern Louisiana, CLA= central Louisiana, WLA = western Louisiana, NTX = north Texas, STX = south Texas). No monitoring was conducted in north Texas.

	ELA	CLA	WLA	NTX	STX
Aerial observation rate	115.8	8.9	14.4	--	0.0
Surface observation rate	6.9	1.6	0.4	--	4.4

TABLE 10

Frequency of individual sea turtles observed by NMFS personnel by distance from removal structure and survey method. Totals are not additive because some individuals were observed in multiple distance categories and survey methods.

Survey Method	<90 No.	<90 %	90-450 No.	90-450 %	450-900 No.	450-900 %	900-1350 No.	900-1350 %	1350-1800 No.	1350-1800 %	>1800 No.	>1800 %	Total No.	Total %
Surface	8	57	3	21	0	0	0	0	0	0	3	21	14	100
Aerial	1	20	2	40	1	20	0	0	1	20	0	0	5	100

Distance (m)

The time periods 1600-2000 hr and 0800-1200 hr displayed the highest values, 0.0097 and 0.0069, respectively.

Observation rates for aerial surveys were calculated for only two time periods because surveys were flown only during daylight hours and sample size was small. Rates for 0600-1200 hr and 1200-1900 hr were 0.0188 and 0.0354, respectively (Figure 4b).

Explosives

Amount of explosives used was generally comparable to the number of structures removed and the months, depths, and areas in which the removals occurred (Figures 5 and 6a & b). A total of 16,204 kg of explosives was detonated in 1993. Averages by structure type were 165 kg per platform, 37 kg per caisson, 23 kg per casing stub, and 16 kg per flare pile.

Impacts on sea turtles

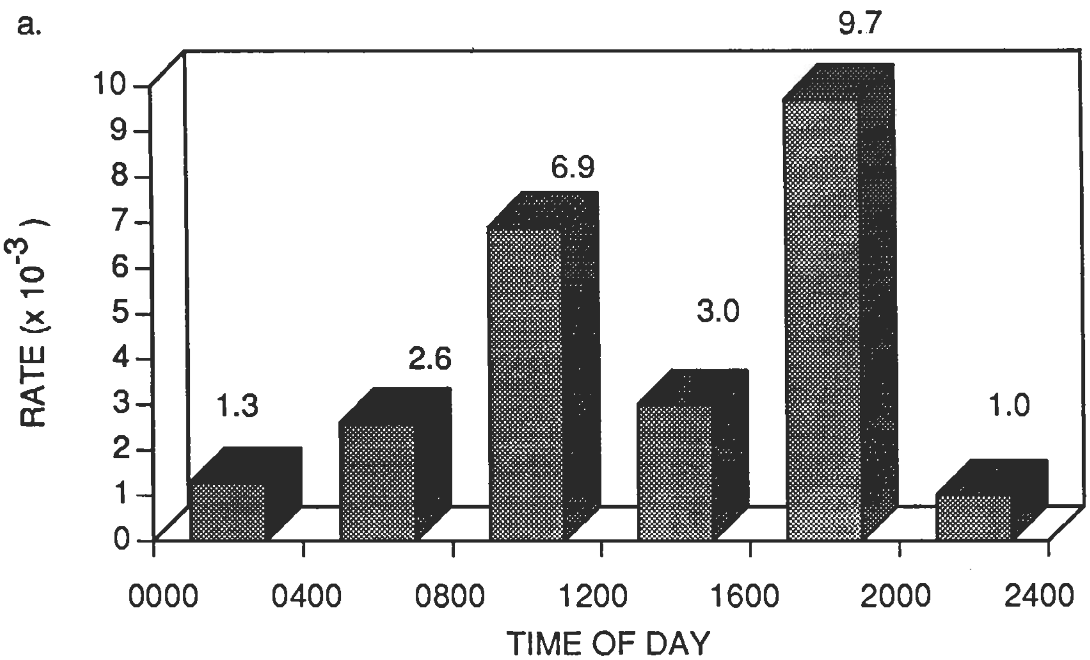
Injury and mortality of sea turtles due to underwater explosions was not reported in 1993, although there is earlier evidence of injury and mortality (Klima et al. 1988; Gitschlag and Hale[2]). One green sea turtle was captured and removed from the water prior to detonations thereby precluding any impacts due to explosives.

Fish mortality

Fish killed by underwater explosions either sank to the sea floor or floated to the surface. Although data were unavailable for the former source of mortality, the surface fish kill was estimated at 63,500. Of these, approximately 58,300 were killed during the removal of platforms, 5,000 at caissons, 200 at casing stubs, and none at flare pile removals. The estimated number of dead, floating fish by structure type was 650 per platform, 140 per caisson, and 100 per casing stub. Estimates of the number of fish killed by geographic area and depth generally corresponded with peaks in explosives use (Figures 6a & b and 7a). Exceptions were identified by calculating the ratio of estimated fish kill per kg of explosive. Highest ratios were 6.1 and 5.7 for western and central Louisiana in 30-45 m depths. The dominant species in descending order of abundance included red snapper (*Lutjanus campechanus*), Atlantic spadefish (*Chaetodipterus faber*), sheepshead (*Archosargus probatocephalus*), blue runner (*Caranx fusus*), lane snapper (*Lutjanus synagris*), mangrove snapper (*Lutjanus griseus*), vermilion snapper (*Rhomboplites aurorubens*), and tomtate (*Haemulon aurolineatum*).

Marine mammals

Observational data provided a crude index of marine mammal activity at structure removal locations. Sightings totaled over 1700 and included primarily the Atlantic bottlenose dolphin, *Tursiops truncatus*, although spotted dolphin, *Stenella plagiodon*, were also reported. Marine mammals were observed at 56 of 77 lease blocks monitored or 73%. On average, 17 dolphin sightings were recorded per platform removal, 5 per caisson removal, 31 per casing stub removal, and zero per flare pile removal. The highest number of dolphin sightings occurred in western and central Louisiana at depths of 15-30 and 30-45 m (Figure 7b). These areas also ranked in the top five for monitoring effort. The number of sightings in central Louisiana at 30-45 m depths was exceptionally high, more than double any other value. In contrast, marine mammal sightings in central Louisiana at 0-15 m depths were very low in relation to the level of monitoring effort.



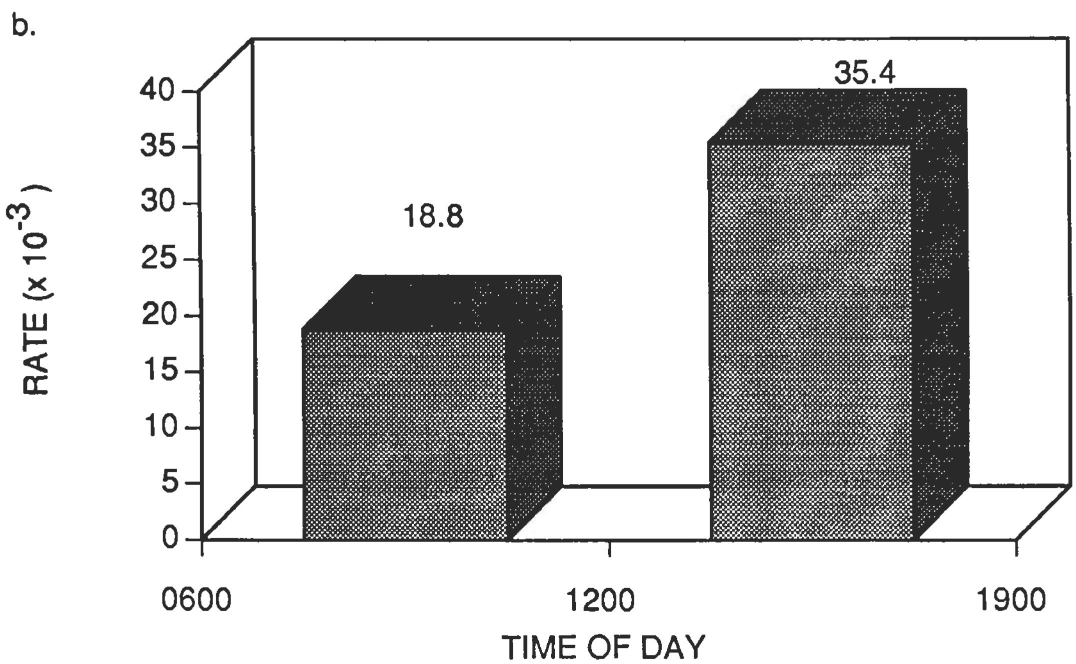


Figure 4. a. Rate (sightings per monitoring hour x 10^{-3}) of sea turtle sightings from surface surveys by time of day, and b. Rate (sightings per monitoring hour x 10^{-3}) of sea turtle sightings from aerial surveys by time of day. Aerial surveys were only conducted during daylight hours.

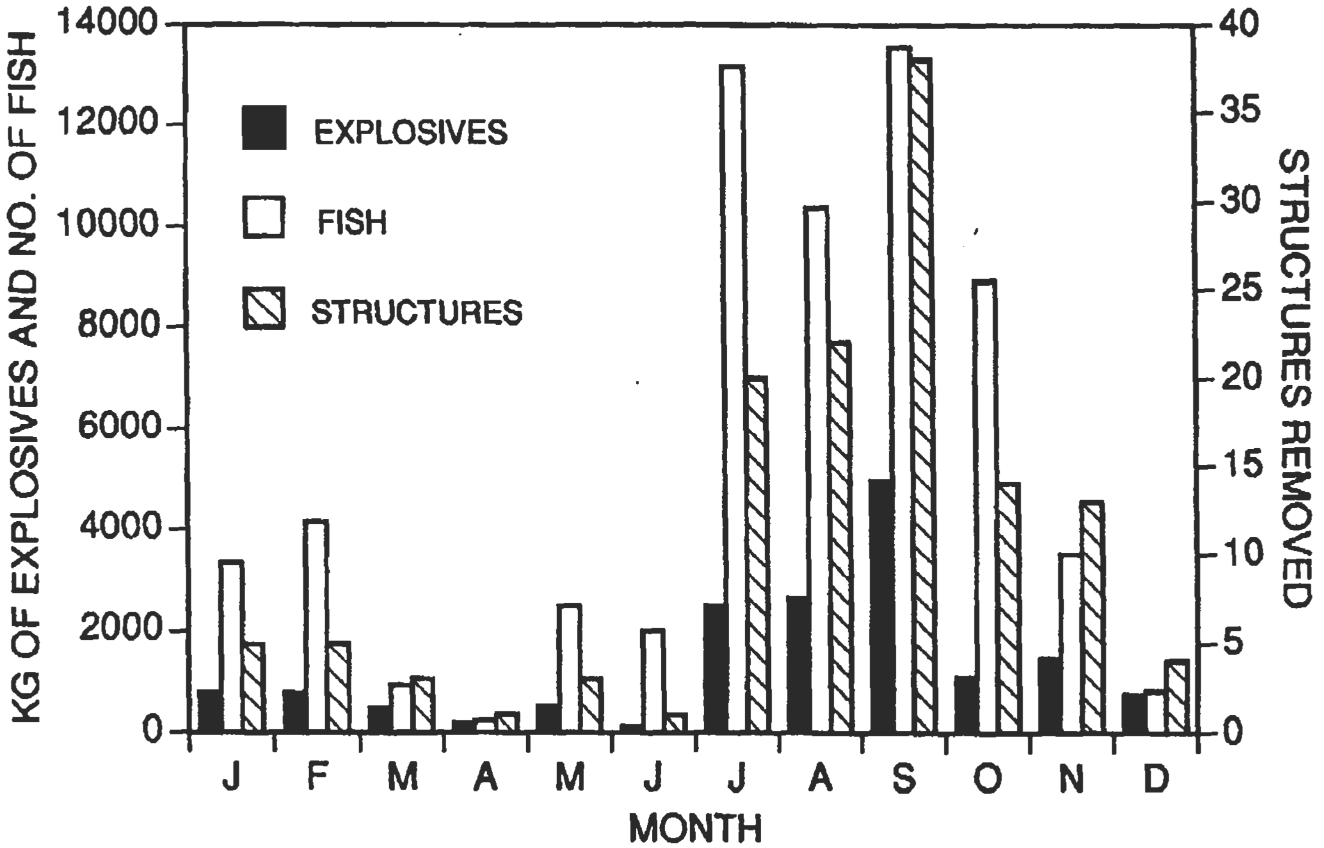


Figure 5. Estimated number of dead, floating fish, kilograms of explosives used, and structures removed by month.

DISCUSSION

Aerial and surface surveys

The aerial observation rate of sea turtles was ten times higher than the surface rate. This value was approximately the same as the six year average (1986-1991), which attests to the superiority of aerial surveys. However, results were less consistent than in earlier years. The failure of aerial surveys to detect sea turtles in south Texas when surface surveys identified 4 individuals may be due to several factors. Dive duration of sea turtles can easily exceed the 30 minute flight time of aerial surveys, and sea turtles may have been undetected because they were submerged during helicopter surveys. Alternatively, the turtles observed during surface surveys may have moved out of the area prior to commencement of aerial surveys.

Months and areas with high sea turtle observation rates often varied between aerial and surface surveys. The causes of these differences were not positively identified but were probably related to small sample size. Sea turtles are listed as threatened and endangered because they are relatively few in numbers. Consequently, encounters with sea turtles are infrequent events.

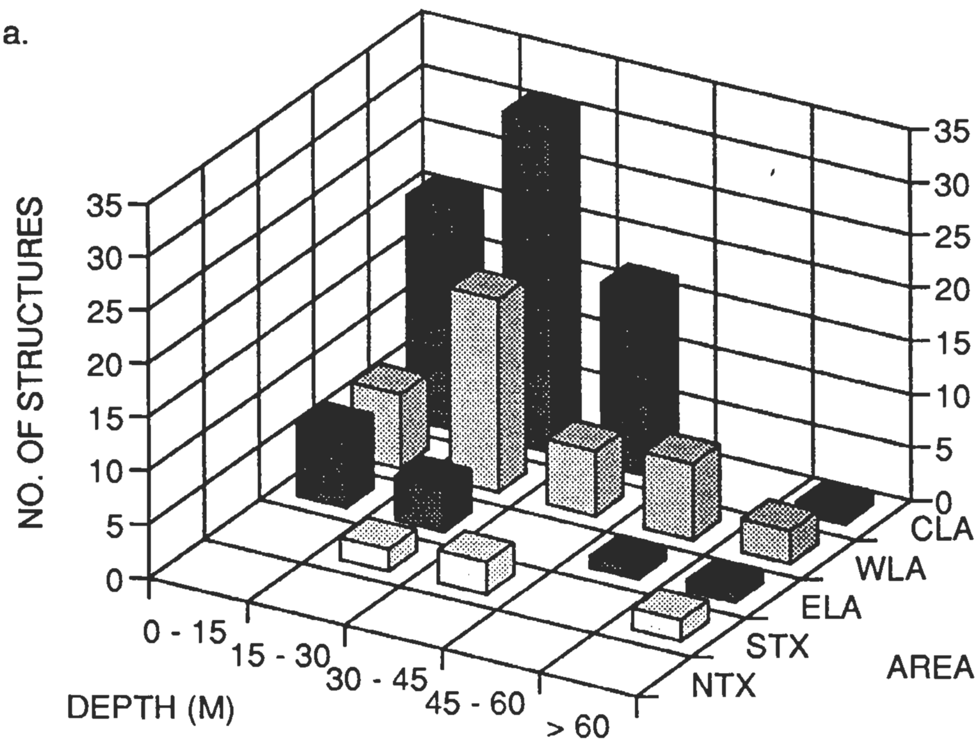
Explosives

Although the amount of explosives used per caisson and casing stub in 1993 was similar to the six year average (1986-1991 Gitschlag and Hale[2]), the weight of explosives used per platform more than doubled in 1992 (Gitschlag and Herzceg 1994) and continued to increase in 1993. This occurred despite a decrease from 11 to 7 in the average number of pilings (including pilings, skirt pilings, conductors, dolphin pilings, and flare pilings) for each platform removal. On average, more explosives were used to sever each piling than in the past.

Impacts on sea turtles

The dominant species of turtle observed at explosive structure removals is the loggerhead which is classified as a threatened species in contrast to the other turtle species which are endangered. Impacts of explosive removals on sea turtles are not easily assessed primarily because turtle behavior makes observations difficult. Sea turtles in temperate latitudes generally spend less than 10% of their time at the surface (Byles 1989; Kemmerer et al. 1983; Nelson et al. 1987; Renaud and

a.



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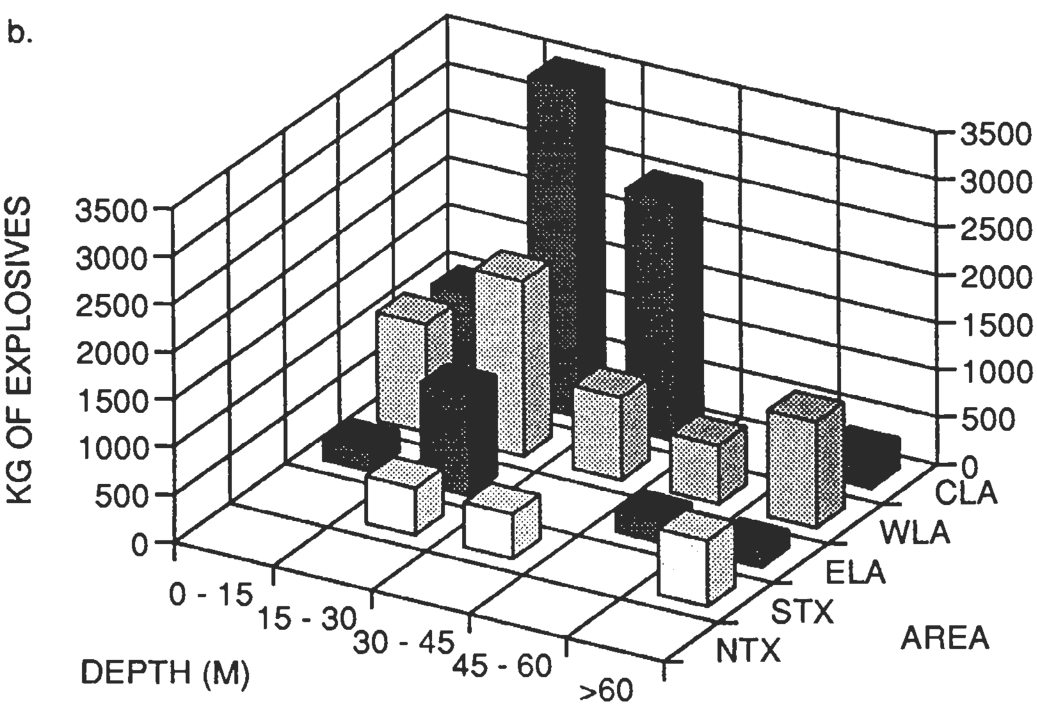

Figure 6. a. Number of explosive structure removals by area (NTX=north Texas, STX=south Texas, ELA=eastern Louisiana, WLA=western Louisiana, CLA=central Louisiana) and depth (data include four monitored platforms that were removed without explosives), and b. Explosives (kg) use by area (NTX=north Texas, STX=south Texas, ELA=eastern Louisiana, WLA=western Louisiana, CLA=central Louisiana) and depth.

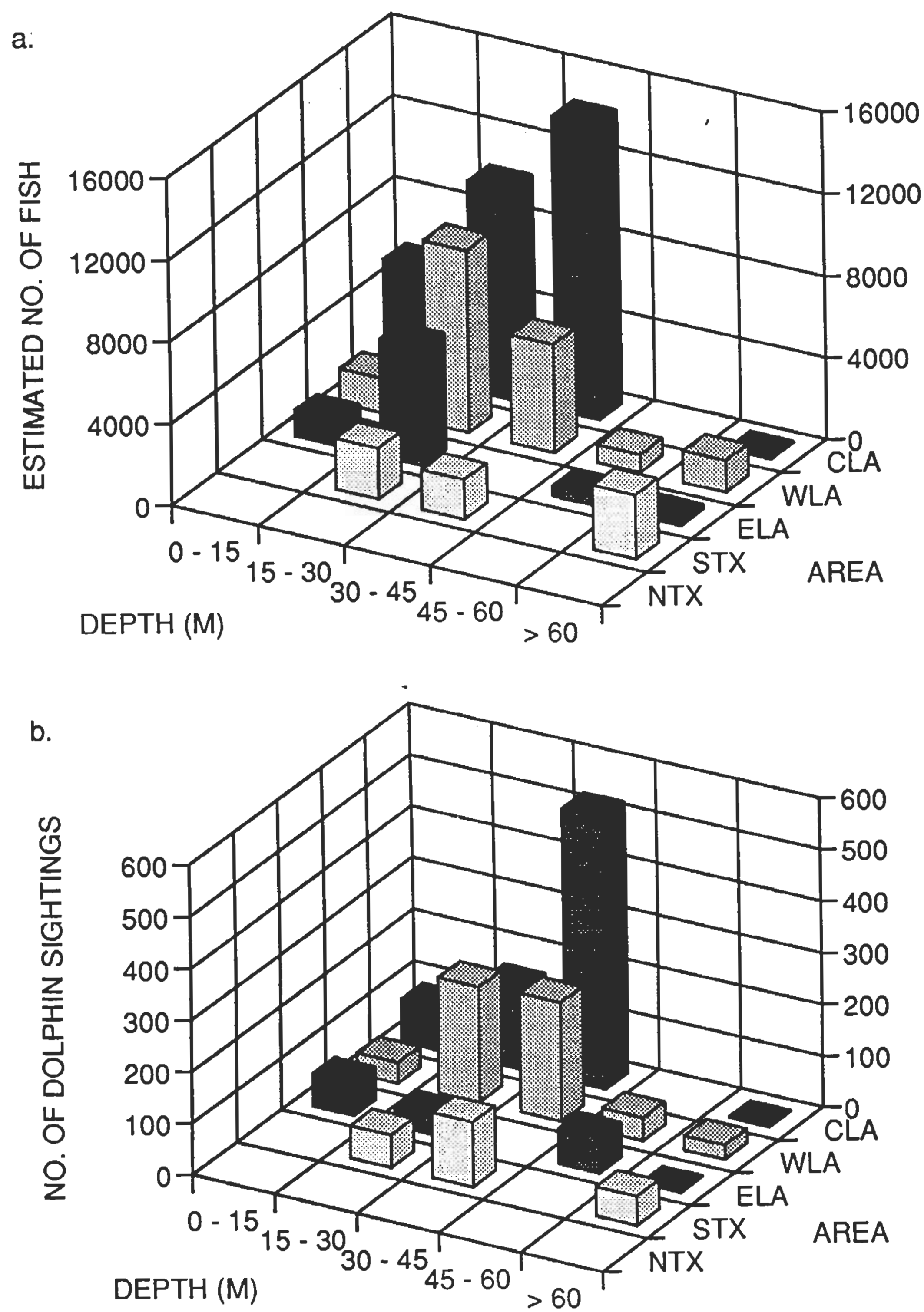

Figure 7. a. Estimated number of dead, floating fish by area (NTX=north Texas, STX=south Texas, ELA=eastern Louisiana, WLA=western Louisiana, CLA=central Louisiana) and depth, and b. Dolphin sightings by area (NTX=north Texas, STX=south Texas, ELA=eastern Louisiana, WLA=western Louisiana, CLA=central Louisiana) and depth.

Carpenter 1994; Renaud submitted) and dive durations can exceed one hour (Byles 1989; personal observation by author). Injured sea turtles that are capable of swimming return to the surface while moribund turtles sink to the sea bottom. Although federal regulation (30 CFR 250.4(b), NTL No. 92-02) requires the use of trawls to verify structure removal locations are clear of obstructions and debris present as a result of oil and gas activities, this procedure is ineffective in collecting impacted sea turtles because contractors have up to 60 days after removal to complete the work. In addition, explosives are detonated over periods of days, weeks, and even months during platform removals, and carcasses can be removed from the area by currents or predators. Without a thorough survey of the sea floor after each detonation, only a conditional assessment of impacts can be made.

With an estimated 1,000 structures or more planned for removal between 1990 and 2000 (National Research Council Marine Board 1985), there is considerable potential for sea turtles to be adversely impacted. High levels of mortality could result if explosives are used when sea turtles occur in aggregations such as during breeding and occasionally during feeding. The monitoring program described here should identify such situations and provide advance notice to managers who can require the implementation of special safety precautions. However, compared with incidental capture in fishing gear, degradation of nesting habitat, and poaching (Henwood and Stuntz 1987; Federal Register 1987; Magnuson et al. 1990; Redfoot et al. 1990; Ehrhart et al. 1990; Broadwell 1991; Donnelly 1991; Irvin 1991; LeBuff and Haverfield 1991), explosive structure removals have had a relatively minor impact on sea turtles.

Sea turtles were observed at 13% of the structures monitored. Aerial surveys were ten times more effective than surface surveys in detecting the presence of sea turtles. Dolphins occurred much more frequently than sea turtles at structure removals. No sea turtles or marine mammals were reported injured or killed by explosives during 1993. Estimates of dead, floating fish indicated mortalities were highest for red snapper, Atlantic spadefish, and sheepshead.

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