Sea Turtle Observations at Explosive Removals of Energy Structures

GREGG R. GITSCHLAG and BRYAN A. HERCZEG

Introduction

In July 1992 the total number of oil and gas production platforms[1] in the Gulf of Mexico was 3,852. Not included in this number were smaller, nonproducing structures such as well jackets and caissons. Federal regulations require removal of all structures within 1 year after lease termination[2]. Plastic explosives are usually the most cost effective means to remove structures.

The potential impact of underwater explosives on threatened and endangered marine species has been a serious concern since 1986. In that year 51 dead sea turtles were found on upper Texas beaches during mid-March to mid-April following a series of 22 underwater explosions to remove offshore oil field structures (Klima et al., 1988). Later that year, NOAA's National Marine Fisheries Service (NMFS) and the Interior Department's Minerals Management Service (MMS), the agency responsible for managing oil and gas resources in Federal waters, held an official consultation under Section 7 of the Endangered Species Act of 1973. As a result, oil and gas companies were required to obtain an MMS permit prior to using explosives in Federal waters. Included in the permit was an Incidental Take Statement prepared by NMFS describing requirements to protect sea turtles in the area (Table 1). Among these requirements was the use of trained observers to monitor for sea turtles. Procedures for structure removals in state waters were similar except that permits were obtained from the U.S. Army Corps of Engineers (COE).

The observer program described in the Incidental Take Statement began in March 1987 (Gitschlag and Hale[3]). Operating costs for the program were passed on to oil and gas companies that used explosives in their structure removal operations. This report summarizes the 1992 findings of the NMFS observer program in the Gulf of Mexico (Fig. 1).

Materials and Methods

The Incidental Take Statement prepared by NMFS under the auspices of the Endangered Species Act defines requirements designed to protect sea turtles from the use of underwater explosives during salvage of offshore structures. Key requirements of the Incidental Take Statement include use of qualified observers to monitor for sea turtles beginning 48 hours prior to detonations, prohibition of nighttime detonations, 30 minute pre- and post-detonation aerial surveys, diver surveys to be conducted before and after detonations in cases where a sea turtle is observed, and delaying multiple detonations of explosive charges by at least 0.9 seconds to reduce the maximum pressure gradient generated by the explosion (Table 1).

Observers collected a variety of data including documentation of date, time, and duration of all sea turtle and marine mammal sightings; estimated distance of sea turtles and marine mammals from the detonation site; duration of monitoring by day, night, and aerial survey; estimation of the number of dead fish floating on the surface after each detonation; and identification and

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 914 meters of the structure, detonations will be delayed and the aerial survey repeated.
4. No detonations will occur at night.
5. During salvage-related diving, divers must report sea turtle and dolphin sightings. If sea turtles are thought to be resident, pre- and post-detonation diver surveys must be conducted.
6. Detonation of sequential explosive charges must be staggered by at least 0.9 seconds to minimize cumulative effects of the explosions.
7 Avoid use of "scare" charges to frighten away sea turtles which may actually be attracted to feed on dead marine life.
8. Removal company must file a report summarizing the results.

---

[1] Barney Congdon, Regional Public Affairs Officer, Minerals Management Service, 1201 Elmwood Park Boulevard, New Orleans, LA 70123. Personal commun.

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

[3] 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.

The authors are with the Galveston Laboratory, Southeast Fisheries Science Center, National Marine Fisheries Service, NOAA, Galveston, TX 77551-5997.

ABSTRACT—Observers were placed at offshore sites to monitor and protect sea turtles during explosive removals of oil and gas structures in the Gulf of Mexico off Louisiana and Texas. Data collected during more than 6,500 hours of monitoring at 106 structure removals in 1992 provided information on sea turtle distribution. Eighteen individuals were observed including 10 loggerheads, 2 leatherbacks, 1 hawksbill, and 5 unidentified sea turtles. The observation rate (individuals per monitoring hour) of sea turtles was about 30 times higher during aerial surveys than during day or night surface surveys.

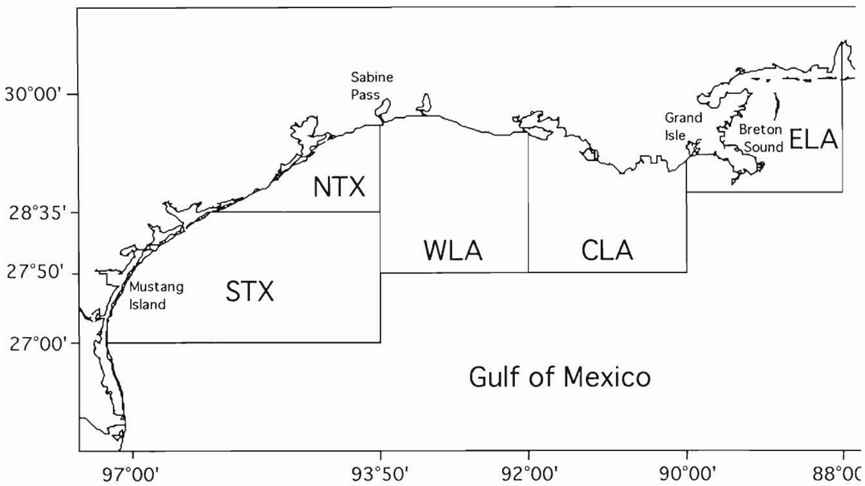


Figure 1.—Partitioning of study area into five regional geographic areas (ELA = eastern Louisiana, CLA = central Louisiana, WLA = western Louisiana, NTX = north Texas, and STX = south Texas).

total length measurements of a sample of these dead fish. Two observers working alternate shifts conducted discontinuous, round the clock monitoring beginning at least 48 hours prior to detonation of explosives. Monitoring often exceeded 48 hours due to delays in salvage operations and to removals that required multiple detonations extending over several days.

Pre-detonation and post-detonation aerial surveys covering a 1,600 m radius around the removal site were conducted by helicopter within 1 hour of a detonation. Surveys were flown during daylight hours at altitudes of 150–210 m and speeds of 110–150 km/hour. Two NMFS observers flew the pre-detonation surveys, but only one performed the post-detonation aerial surveys. The second observer collected a representative sample of dead, floating marine life. When seasonally heavy workloads resulted in only one observer on site, the single observer worked up to 18 hours per day performing surface and aerial surveys. Although the single observer was unable to perform post-detonation collection of dead, floating marine life, an estimate of the number of dead floating fish was recorded after each detonation. Aerial surveys were not conducted at some structures primarily due to inclement weather.

Data collected at explosive structure removals plus four additional platforms which were mechanically cut or toppled by hurricanes, were analyzed using the chi-square test. Because sightings of threatened and endangered species of sea turtles occurred infrequently and resulted in some cells with no observations, categories within test parameters sometimes were combined.

Terminology and Data Analysis

Some of the terms used in this report require definition. A sea turtle "sighting" was recorded whenever a sea turtle was observed. If one sea turtle was observed on two separate occasions or if two sea turtles were observed simultaneously, two sightings were recorded. Each sea turtle observed was counted as a unique "individual" unless there was evidence, for example, carapace size or barnacle pattern, indicating that the same individual was observed on multiple occasions. It could not always be determined when repetitive sightings occurred. Consequently, the number of individual sea turtles shown in the tables and figures represents a maximum value of the actual number observed.

The distinction was made between sightings of sea turtles by trained NMFS personnel and non-NMFS personnel. Monitoring effort for non-NMFS personnel was not quantified. Any observation of a sea turtle that was personally witnessed by an NMFS employee was recorded as an NMFS sighting, even if the sea turtle was initially pointed out by non-NMFS personnel. Observation "rates" were calculated 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.

The loggerhead is the most frequently identified sea turtle that occurs at offshore platforms. Structural members of the platform can be seen in the photo.

Three categories of visual surveys were defined: Day, night, and aerial. Day and night surveys were conducted from vessels and platforms and collectively were referred to as surface surveys. Aerial surveys were conducted during daylight hours from helicopters. Monitoring hours for surface surveys were determined by summing man–hours of observations. When calculating observation rates of sea turtles for aerial surveys, effort equalled the sum of flight times regardless of the number of people in the helicopter.

Three categories of structure types were defined. A "platform" referred to any multi-pile structure and a "caisson" to a structure with only a single pile penetrating the sea floor. The term "casing stub" referred to a single pile well conductor or caisson that did not penetrate the surface of the water. To facilitate analysis by geographic region, the study area was divided into five regions: Western Louisiana, central Louisiana, eastern Louisiana, north Texas, and south Texas (Fig. 1).

A geyser of water blasts from a piling during the explosive removal of an offshore platform. Plastic explosives are detonated inside the hollow legs of the platform at a depth of 5 m below the sea floor. The part of the platform standing above water, referred to as the deck, has already been cut with torches and lifted onto a barge (lower right) by a large crane.

Results

Overview of Explosive Structure Removals

A total of 106 offshore structure removals were monitored including 77 platforms, 26 caissons, and 3 casing stubs (Table 2). The majority of removals occurred in relatively shallow water, with 42% in water ≤ 15 m, 30% in 15–30 m, 22% in 30–60 m, and 7% in > 60 m (Table 2). Sixty–four percent of platform removals and 100% of caisson removals occurred in water ≤ 30 m deep. This contrasts with only 33% (1 of 3) of casing stub removals in that depth zone. The deepest removal was a platform in 93 m of water.

Table 2.—Frequency of monitored removals by structure type and water depth.

Water depth (m)	Platform	Caisson	Casing stub	Total	Percent
≤15	25	19	0	44	42
15–30	24	7	1	32	30
30–60	21	0	2	23	22
60–90	6	0	0	6	6
90–120	1	0	0	1	1
Total	77	26	3	106	

Monitoring of structure removals extended from Breton Sound, Louisiana, westward across the Gulf of Mexico to Mustang Island, Texas. Approximately 77% of all removals occurred in central and western Louisiana waters between Grand Isle in the east and the Sabine River in the west. Eastern Louisiana and north Texas each had 6% of structure removals while south Texas had 11%.

Energy and salvage companies usually scheduled removals during summer and fall to reduce delays caused by foul weather. Most (75%) explosive structure removals occurred from June through December.

Monitoring Effort

Monitoring effort totaled 6,516 hours which included 3,729 day, 2,617 night, and 170 aerial survey hours. Most effort occurred in central and western Louisiana in 0–30 m water depths (Fig. 2, 3).

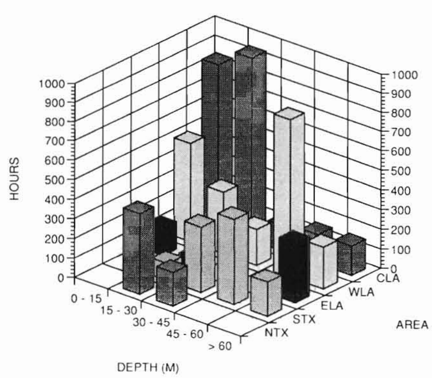


Figure 2.—Surface monitoring effort by depth and geographic area (NTX = north Texas, STX = south Texas, ELA = eastern Louisiana, WLA = western Louisiana, CLA = central Louisiana).

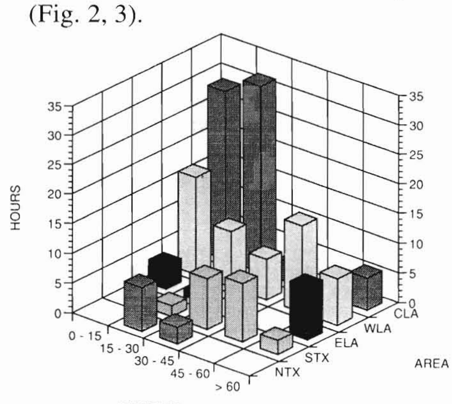


Figure 3.—Aerial monitoring effort by depth and geographic area (NTX = north Texas, STX = south Texas, ELA = eastern Louisiana, WLA = western Louisiana, CLA = central Louisiana).

Sea Turtle Observations by Species

NMFS personnel recorded 45 sightings of 18 individual sea turtles including 10 loggerhead, *Caretta caretta*; 2 leatherback, *Dermochelys coriacea*; 1 hawksbill, *Eretmochelys imbricata*; and 5 unidentified sea turtles (Table 3). Combining observations from NMFS and non-NMFS personnel yielded a total of 61 sea turtle sightings of 27 individual sea turtles.

Sea Turtle Observations by Survey Method

NMFS observers recorded 20 sightings of 6 individual sea turtles during day surveys, 14 sightings of 4 individuals during night surveys, and 11 sightings of 8 individuals during aerial surveys. Although sea turtle observation rates for day and night monitoring were similar (0.0016 and 0.0015), the observation rate for aerial surveys was approximately thirty times higher (0.0468, Table 4). Similarly, the frequency of sea turtle observations collected during day, night, and aerial surveys was significantly different ($P<0.0005$) from expected frequencies while that for day and night observations was not ($0.9<P<0.95$, Table 5).

Sea Turtle Observations by Structure Type

NMFS personnel reported 38 sightings of 12 individual sea turtles at platform removals, 5 sightings of 5 individuals at caisson removals, and 2 sightings of 1 individual at casing stub removals (Table 6). Non–NMFS personnel reported an additional 16 sightings at platform removals. Observation rates for surface surveys were similar at platforms and caissons (0.0016 and 0.0013), although rates for aerial surveys were seven times higher at caissons than at platforms (0.1477 and 0.0218). The small sample size precluded statistical analysis. The number of individual sea turtles observed by NMFS personnel per structure removal was 0.16 at platforms, 0.19 at caissons, and 0.33 at casing stubs. Sea turtles were observed at 20% of the structures monitored.

Sea turtle activity was especially high at some structures. Two or more individual sea turtles were observed at four locations, three in north Texas and one in central Louisiana waters. Except for one caisson, all structures were platforms. One Texas location included a complex of three platforms. Three of the removals were in water depths of 16–19 m, and the other was in 49 m.

Sea Turtle Observations by Water Depth

Thirty-one of 45 total NMFS sightings occurred in water depths of 15–60 m. This represented 14 of 18 (78%) individuals (Table 7). Both aerial and surface sea turtle observation rates were highest for 15–30 m depths (0.0787 and 0.0028, respectively, Fig. 4, 5). The aerial observation rate for less than or equal to 15 m depths was 0.0615 compared with a surface observation rate of zero.

Depth categories were combined to facilitate chi-square analysis. There was no significant difference in the number of sea turtles observed in 0–30 and >30 m depth zones during surface surveys ($0.9<P<0.95$, Table 5).

Sea Turtle Observations by Month

Sea turtle observation rates obtained from surface surveys were highest during June through October (0.0010–0.0053, Table 8). No sea turtles were observed in any other month except March which had a rate (0.0032) com-

Table 3.—Frequency of sea turtle sightings and individuals. Observations from both NMFS and non-NMFS personnel are included in the "Total" column.

Species	Sightings NMFS	Sightings Total	Individuals NMFS	Individuals Total
Loggerhead	26	32	10	15
Leatherback	3	3	2	2
Hawksbill	10	16	1	1
Unknown	6	10	5	9
Total	45	61	18	27

Table 4.—Frequencies 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" rows.

Item	Platform	Caisson	Casing stub	Total
Sightings				
NMFS	38	5	2	45
Total	54	5	2	61
Individuals				
NMFS	12	5	1	18
Total	21	5	1	27
Monitoring hours				
Day	3,202	468	59	3,729
Night	2,275	322	20	2,617
Aerial	137	27	6	170
Observation rate[1]				
Day	1.6	2.1	0	1.6
Night	1.8	0	0	1.5
Day & Night	1.6	1.3	0	1.6
Aerial	21.8	147.7	160.5	46.8

[1] Individuals/h × 10^{-3}.

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	No.	P	Significant
Day, night, & aerial surveys	All structures	18	<0.0005	*
	Platforms	12	<0.0005	*
Day & night surveys	All structures	10	$0.0<P<0.95$	
Depth (0–30, >30m)	Day & night surveys	10	$0.9<P<0.95$	
Time of day (6 × 4 h periods)	Day & night surveys	34	$0.2<P<0.1$	
Time of day (0600–1200, 1200–1900)	Aerial surveys	12	$0.8<P<0.9$	

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	No. of structures removed	Sightings NMFS	Sightings Total	Individuals NMFS	Individuals Total	Rate × 10^{-3} Day	Rate × 10^{-3} Night	Rate × 10^{-3} Aerial
Platform	77	38	54	12	21	1.56	1.76	21.8
Caisson	26	5	5	5	5	2.14	0	147.7
Casing stub	3	2	2	1	1	0	0	160.5
Total	106	45	61	18	27			

parable to those obtained during summer months. Low rates for surface surveys during winter and spring were not the result of low monitoring effort which ranged from 186–680 h/month (Table 8). However, only 25% of structures were removed during January through May.

Observation rates from aerial surveys were zero for all months except July (0.1842) and December (0.0909). Aerial survey effort was as low as 4 hours during February.

Sea Turtle Observations by Geographic Area

Sea turtle observation rates from aerial surveys were highest in central (0.1002) and western Louisiana (0.0183), while rates were zero in all other areas (Table 9). Rates for surface surveys were highest in north (0.0051) and south Texas (0.0029). No sea turtles were observed in eastern Louisiana despite the presence of a loggerhead nesting beach in the Chandeleur Islands.

Sea turtle Observations by Distance from Structure Removals

Estimates of the distance at which sea turtles were observed from the structure removal site were summarized for each survey method (Table 10). Of the sea turtles observed during surface surveys, 82% were within about 90 m of the removal structure, while 91% of sea turtles observed during aerial surveys were at distances > 90 m.

Sea Turtle Observations by Time of Day

Surface observation rates for sea turtle sightings were calculated for sequential 4-hour time periods of the 24-hour day beginning at midnight. There was no significant difference ($0.2<P<0.1$) in the distribution of sightings during these six time periods (Table 5). Rates ranged from a low of 0.0014 during 0000–0400 h to a high of 0.0092 during 0400–0800 h (Fig. 6).

Observation rates for aerial surveys were calculated for only two time periods because surveys were only flown during daylight hours and sample size was small. Rates for 0600–1200 hr and 1200–1900 h were 0.0744 and 0.0650, respectively (Fig. 7). The frequencies of sea turtle sightings during these time periods were not significantly different ($0.8<P<0.9$, Table 5).

Explosives Use

A total of 12,620 kg of explosives was detonated in structure removal operations. Explosives use was highest from June through October (Fig. 8). The quantity of explosives used by area and depth was usually similar to the number of structures removed (Fig. 9, 10). Peaks in explosives use and structure removals occurred in western and central Louisiana in the 0–30 m depth zone. An average of 152 kg of explosives was used per platform removal, 32 kg per caisson, and 34 kg per casing stub. Injury and mortality of sea turtles and marine mammals due to underwater explosions was not documented in 1992.

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		Total	
Depth (m)	Sightings	Individuals	Sightings	Individuals	Sightings	Individuals	Sightings	Individuals
0–15	3	2	1	1			4	3
15–30	20	5	4	4	0	0	24	9
30–60	5	4			2	1	7	5
60–90	10	1					10	1
90–122	0	0					0	0
Total	38	12	5	5	2	1	45	18

Table 8.—Surface and aerial monitoring effort, number of individual sea turtles observed, and observation rate (individuals per hour × 10^{-3}) by month.

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Surface												
Monitoring hours	300	186	313	456	680	375	957	498	1180	689	292	405
No. of individual sea turtles	0	0	1	0	0	2	1	2	2	2	0	0
Rate × 10^{-3}	0.0	0.0	3.2	0.0	0.0	5.3	1.0	4.0	1.7	2.9	0.0	0.0
Aerial												
Monitoring hours	7	4	8	6	21	10	38	16	32	13	5	11
No. of individual sea turtles	0	0	0	0	0	0	7	0	0	0	0	1
Rate × 10^{-3}	0.0	0.0	0.0	0.0	0.0	0.0	184.2	0.0	0.0	0.0	0.0	90.9

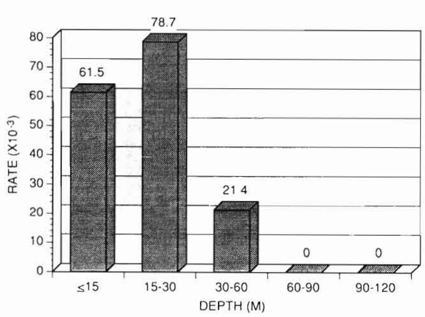


Figure 4.—Aerial observation rates (individual sea turtles per hour x 10^{-3}) by depth zone.

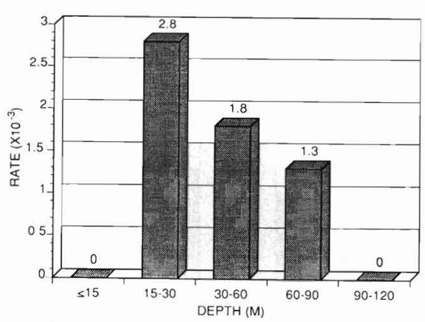


Figure 5.—Surface observation rates (individual sea turtles per hour x 10^{-3}) by depth zone.

Table 9.—Observation rate (individual sea turtles per hour × 10^{-3}) by geographic area (ELA = eastern Louisiana, CLA = central Louisiana, WLA = western Louisiana, NTX = north Texas, STX = south Texas).

Item	ELA	CLA	WLA	NTX	STX
Aerial observation rate	0.0	100.2	18.3	0.0	0.0
Surface observation rate	0.0	0.9	1.0	5.1	2.9

Table 10.—Frequency of individual sea turtles observed by NMFS personnel by distance from removal structure and survey method. Totals are not addable because some individuals were observed in multiple distance categories and survey methods.

	Distance (m)													
	<90		90–450		450–900		900–1,350		1,350–1,800		>1,800		Total	
Survey method	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Surface	9	82	2	18	0	0	0	0	0	0	0	0	11	100
Aerial	1	9	4	36	5	45	0	0	0	0	1	9	11	100

Fish Kill

An estimate of the number of fish killed by explosives during structure salvage was made using data from dead floating fish. These estimates are biased and low since they do not account for dead fish which sank to the sea floor. Nevertheless, the estimated fish kill was 55,094 on the surface. Of these, approximately 51,035 were killed during the removal of platforms, 3,679 at caissons, and 380 at casing stubs. The number of dead, floating fish per structure was 729 per platform, 142 per caisson, and 127 per casing stub. The magnitude of the estimates for geographic areas and depths generally corresponded with peaks in explosives use (Fig. 10, 11). Exceptions were identified by calculating the ratio of estimated fish kill per kilogram of explosive. The highest ratios ranged from 8.1 to 9.8 for the following categories in descending order: South Texas (15–30 m and 45–60 m), central Louisiana (30–45 m), western Louisiana (30–45 m), and central Louisiana (15–30 m). The dominant species in descending order of abundance included Atlantic spadefish, *Chaetodipterus faber*; red snapper, *Lutjanus campechanus*; vermilion snapper, *Rhomboplites aurorubens*; hardhead catfish, *Arius felis*; blue runner, *Caranx fusus*; sheepshead, *Archosargus probatocephalus*; tomtate, *Haemulon aurolineatum*; and lane snapper, *Lutjanus synagris*.

Marine Mammals

Although species identification of marine mammals was frequently impossible, observers reported that the Atlantic bottlenose dolphin, *Tursiops truncatus*, was clearly the dominant species identified. Determining when repetitive sightings of the same individual dolphins occurred was often futile. Consequently, the marine mammal data served primarily as a general index of dolphin activity at the sea surface in the vicinity of structure removals, and was not used to estimate population size.

On average, 22 dolphin sightings were recorded per platform removal, 5 per caisson removal, and 4 per casing

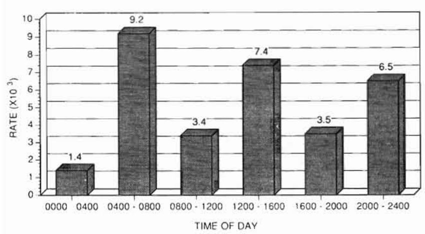


Figure 6.—Rate (sightings per monitoring hour x 10^{-3}) of sea turtle sightings from surface surveys by time of day.

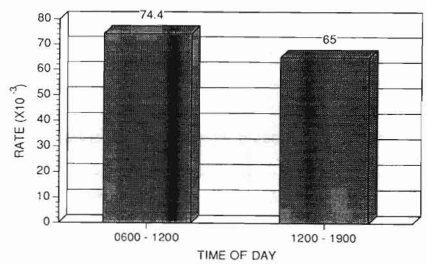


Figure 7.—Rate (sightings per monitoring hour x 10^{-3}) of sea turtle sightings from aerial surveys by time of day (aerial surveys were only conducted during daylight hours).

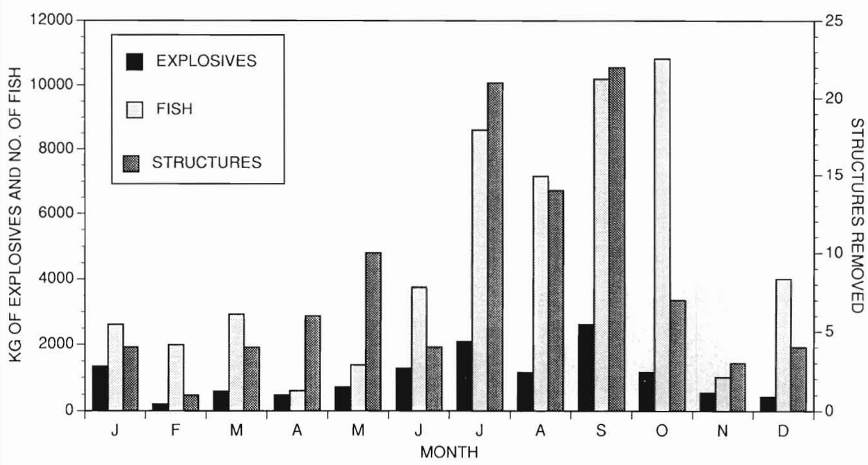


Figure 8.—Estimated number of dead, floating fish, kilograms of explosives, and structures removed by month.

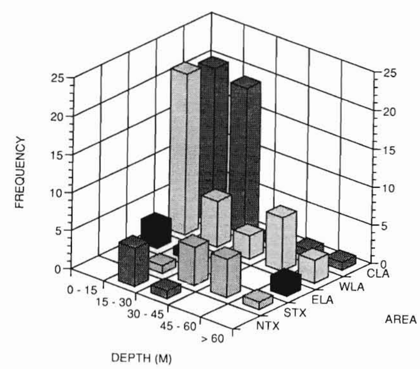


Figure 9.—Number of explosive structure removals by area (NTX = north Texas, STX = south Texas, ELA = eastern Louisiana, WLA = western Louisiana, CLA = central Louisiana) and depth. Data includes four monitored platforms that were removed without explosives.

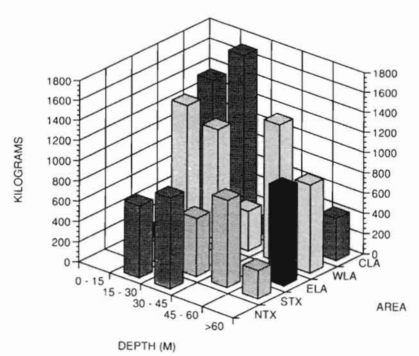


Figure 10.—Explosives (kg) use by area (NTX = north Texas, STX = south Texas, ELA = eastern Louisiana, WLA = western Louisiana, CLA = central Louisiana) and depth.

stub removal. The frequency of dolphin sightings was highest in western and central Louisiana, the areas where monitoring levels were highest (Fig. 12). However, the >60 m depth zone in western Louisiana had a disproportionately higher frequency of dolphin sightings in relation to monitoring effort.

Discussion

Differences Between Aerial and Surface Surveys

The aerial observation rate of sea turtles was thirty times higher than the surface rate. This value was three times greater than the previous 6-year average, which attests to the superiority of aerial surveys.

Months and areas with high sea turtle observation rates often varied for aerial and surface surveys. The causes of these differences were not positively identified but were probably related to small sample size in part due to sea turtle observations being infrequent events.

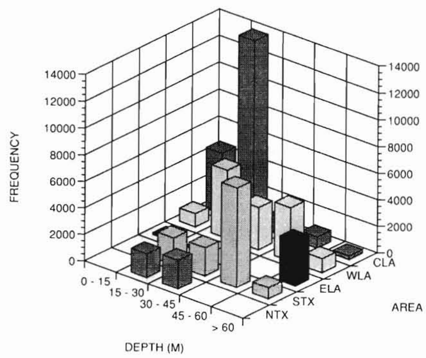


Figure 11.—Estimated number of dead, floating fish by area (NTX = north Texas, STX = south Texas, ELA = eastern Louisiana, WLA = western Louisiana, CLA = central Louisiana) and depth.

Amount of Explosives Used

Although the amount of explosives used in 1992 per caisson and casing stub was similar to the 6-year average determined for 1986–91 (Gitschlag and Hale[3]), the weight of explosives used per platform more than doubled in 1992. This occurred despite a decrease in the average number of pilings (including pilings, skirt pilings, conductors, dolphin pilings, and flare pilings) from 11 to 7 for each platform removal.

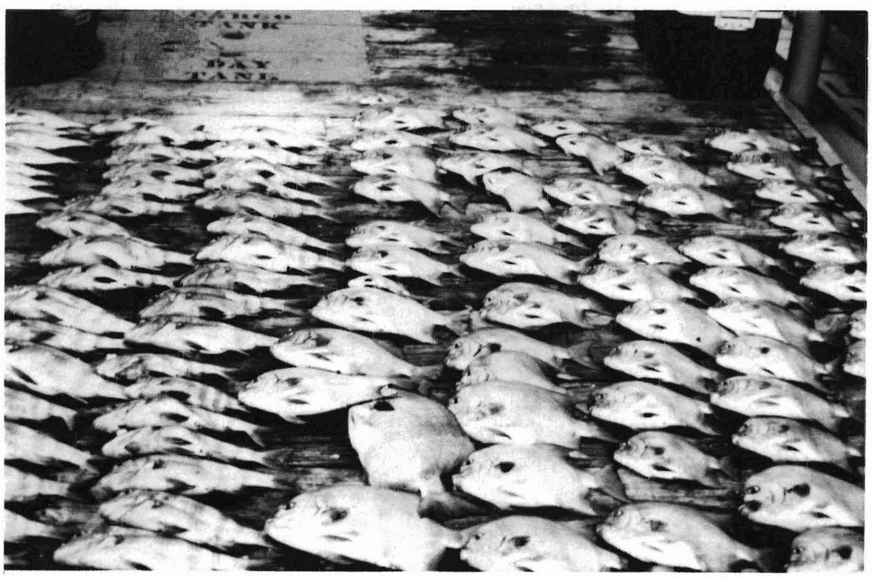
Affinity of Sea Turtles for Structures

Sea turtles have long been known to inhabit areas characterized by topographic relief, such as natural reefs (Booth and Peters, 1972; Stoneburner, 1982; Witzell, 1982). Oil and gas structures serve as artificial reefs which have been shown to provide habitat for sea turtles (Gitschlag and Hale[3]). Another factor that may attract sea turtles to offshore structures is artificial lighting which can serve as a visual cue and a means to aggregate food items such as crabs. Operational platforms, as opposed to caissons, are well lit and can be seen at distances >10 km. Regardless of structure type, artificial lighting at removal operations is provided by salvage vessels which range in size from about 30 to 200 m in length. The presence of salvage vessels alters the habitat at the removal site and may influence sea turtle distribution.

Explosive Structure Removals and Sea Turtle Mortality

With an estimated 1,000 structures or more planned for removal between 1990 and 2000 (National Research Council Marine Board, 1985) it is appropriate to assess the contribution of underwater explosives to sea turtle mortality. The use of underwater explosives in structure removals can kill and injure sea turtles (Klima et al., 1988; Gitschlag and Hale[3]). However, our ability to document and mitigate these impacts is limited. Monitoring the water's surface for sea turtles is not 100% effective. Once observed, there is currently no practical and efficient means of removing a sea turtle from the area impacted by explosives. Although divers have had some success in capturing sea turtles, this procedure is limited to animals resting or sleeping beneath platforms.

While acknowledging the above limitations, it is clear that the relative contribution of underwater explosives to sea turtle mortality pales in comparison to other sources. The number of documented sea turtles impacted by explosives was only two during 1986–91 (Gitschlag and Hale, 1993) and zero in 1992. Five additional sea turtles were captured prior to detonation of explosives and saved from possible injury or death. These numbers are extremely small compared to the more than 11,000 sea turtles estimated to have been killed in shrimp trawls prior to the use of Turtle Excluder Devices (Henwood and



Dead fish collected from the sea surface after explosives are detonated frequently include spadefish and sheepshead as well as red snapper, vermilion snapper, blue runner, and hardhead catfish.

Stuntz, 1987). Other leading sources of sea turtle mortality in addition to capture in fishing gear include 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).

Although the number of documented sea turtles that have been directly saved from injury or death is small, the observer program has provided other benefits. When sea turtle activity was especially high, stringent requirements were placed on energy companies which resulted in a change from explosive to harmless mechanical removal techniques. Prior to the observer program there was no restriction on the amount of explosives used per detonation. In most cases, explosive weight is now limited to 23 kg. Oil and gas companies are more aware of the potential impacts of explosives on sea turtles. On a few occasions energy companies voluntarily used mechanical techniques, but explosives will remain the preferred removal method as long as it is the most economical.

Conclusions

Sea turtles were observed at 20% of the structures monitored. Aerial surveys were thirty times more effective than surface surveys in detecting the presence of sea turtles. Dolphins occurred much more frequently than sea turtles at structure removals. Fish mortalities were highest for Atlantic spadefish, red snapper, and vermilion snapper.

Acknowledgements

We acknowledge the NMFS observers who worked on the study and the cooperation of energy companies and their contractors.

Literature Cited

Booth, J., and K. A. Peters. 1972. Behavioural studies on the green turtle (*Chelonia mydas*) in the sea. Anim. Behav. 20:808–812.

Broadwell, A. L. 1991. Effects of beach renourishment on the survival of loggerhead sea turtle nests. *In* M. Salmon and J. Wyneken (Compilers), Proceedings of the Eleventh Annual Workshop on Sea Turtle Biology and Conservation, p. 21–23. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFC-302, 195 p.

Donnelly, M. 1991. International sea turtle trade and the Pelly Amendment. *In* M. Salmon, and J. Wyneken (Compilers), Proceedings of the Eleventh Annual Workshop on Sea Turtle Biology and Conservation, p. 32–34. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFC-302, 195 p.

Ehrhart, L. M., P. Raymond, J. L. Guseman, and R. Owen. 1990. A documented case of green turtles killed in an abandoned gill net: The need for better regulation of Florida's gill net fisheries. *In* T. H. Richardson, J. I. Richardson, and M. Donnelly (Compilers), Proceedings of the Tenth Annual Workshop on Sea Turtle Biology and Conservation, p. 55–58. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFC-278, 286 p.

Federal Register. 1987. Sea turtle conservation; shrimp trawling requirements; final rule. June 29. 52(124): 24244–24262.

Henwood, T. A, and W. E. Stuntz. 1987. Analysis of sea turtle captures and mortalities during commercial shrimp trawling. Fish. Bull. 85(4):813–817.

Irvin, W. R. 1991. Critical habitat designation: Is it worth the effort? *In* M. Salmon and J. Wyneken (Compilers), Proceedings of the Eleventh Annual Workshop on Sea Turtle Biology and Conservation, p. 64–65. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFC-302, 195 p.

Klima, E. F., G. R. Gitschlag, and M. L Renaud. 1988. Impacts of the explosive removal of offshore petroleum platforms on sea turtles and dolphins. Mar. Fish. Rev. 50(3):33–42.

LeBuff, C. R., Jr., and E. M. Haverfield. 1991. Nesting success of the loggerhead turtle (*Caretta caretta*) on Captiva Island, Florida—a nourished beach, pp. 69–71. *In* M. Salmon and J. Wyneken (Compilers), Proceedings of the Eleventh Annual Workshop on Sea Turtle Biology and Conservation, p. 69–71. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFC-302, 195 p.

Magnuson, J. J., K. A. Bjorndal, W. D. DuPaul, G. L. Graham, D. W. Owens, C. H. Peterson, P. C. H. Pritchard, J. I. Richardson, G. E. Saul, and C. W. West. 1990. Decline of the sea turtles: Causes and prevention. Natl. Res. Counc., Natl. Acad. Sci. Press, Wash., D.C., 190 p.

National Research Council Marine Board. 1985. Disposal of offshore platforms. Nat. Acad. Sci. Press, Wash., D.C., 88 p.

Redfoot, W. E., L. M. Ehrhart, and J. L. Guseman. 1990. Results of marine turtle nesting beach productivity studies conducted in central and south Brevard County, Florida, in 1989. *In* T. H. Richardson, J. I. Richardson, and M. Donnelly (Compilers), Proceedings of the Tenth Annual Workshop on Sea Turtle Biology and Conservation, p. 7–9. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SEFC-278, 286 p.

Stoneburner, D. L. 1982. Satellite telemetry of loggerhead sea turtle movement in the Georgia Bight. Copeia 2:400–408.

Witzell, W. N. 1982. Observations of the green sea turtle (*Chelonia mydas*) in Western Samoa. Copeia 1:183–185.