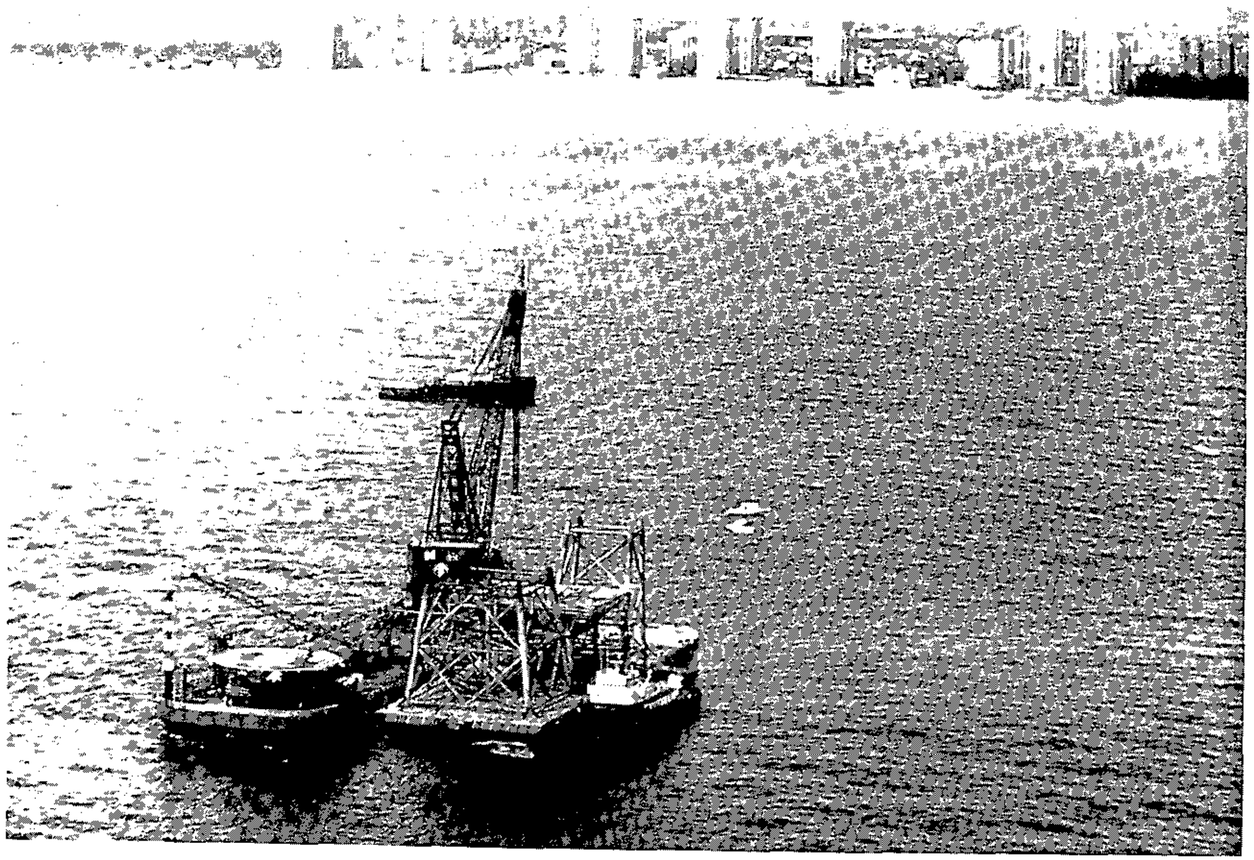

Figure 9. Reef Construction Site.

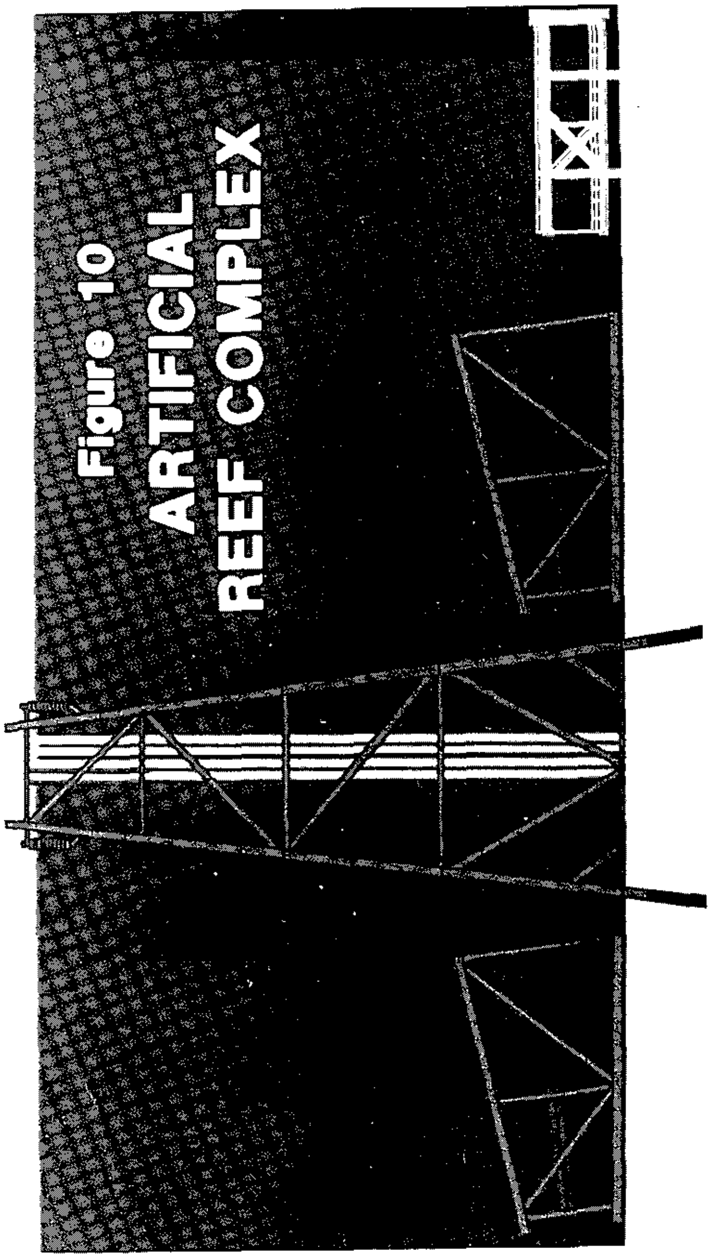
Figure 10
ARTIFICIAL
REEF COMPLEX

Table 1

Water Depth of Structures Installed in the Gulf of Mexico, off California, and off Alaska as of 1983

Water Depth (feet)	Number of Structures Gulf of Mexico	California	Alaska	Total
0-20	1,152			1,152
21-50	1,414			1,414
51-100	650	7	14	671
101-150	329			329
151-200	240	10		250
201-300	206			206
301-400	52	6		58
401-500	5			5
501-900	4			4
900	4			4
Total	4,056	24	14	4,094

[a]Depth categories for California data are < 100 feet, 100 feet -200 feet, 200 feet -400 feet, > 400 feet.
[b]All Cook Inlet, Alaska, platforms are in water approximately 100 feet deep.

Source: National Research Council Marine Board. 1985. Disposal of Offshore Platforms.

Platform Removal: Reuse, Reef, or Scrap?

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Introduction

The nominal design basis for oil and gas drilling and producing structures for the Gulf of Mexico is 20 years. By no means does a "20-year life" indicate that the structure is inadequate after20 years. Indeed, the design life is more of a tool of definition to aid in the optimization of designs than a boundary condition for ultimate useful life.

There are currently in excess of 4,000 structures in the Gulf of Mexico associated with various aspects of oil and gas production. The structural types vary from single, oversized well caissons at one end of the spectrum to multiple-legged platforms designed to support simultaneously a large number of wells, a workover or drilling rig, and the production equipment necessary to process fluids from those wells into oil and gas sales pipelines.

The range of water depths in which these activities take place varies from just a few feet to over 1,000 ft (304.8 m). The design, size, and weight of required steel varies, dependent not only on the array of functions that will occur and on site-specific environmental conditions, but also with the individual preferences and opinions of the operating companies involved.

Although definitions, opinions, and designs may vary somewhat between our companies, the ultimate reason for the initial and continued existence of a given structure is the economical production and sale of hydrocarbons. When the time arrives that the costs of maintenance, operating personnel, transportation, fuels and other items outstrip the available income, a structure has reached the point of existing as a liability instead of an asset.

While this paper will address only the economic details of one project, there are also decisions dealing with environmental, social, and legal issues. Each of these areas must be reviewed and conditions that change with time must be considered in the overall planning of a platform abandonment.

Until very recently the existing State and/or Federal requirements concerning such structures called for complete removal to a depth of 16.4 ft (5 m) below the natural surrounding seabed. The options that were available following this required removal gave rise to the title of this paper: "Reuse, Reef or Scrap." The authors will use a site-specific example from Amoco Production Company that, due to some specific factors, allows a review of some of the various points that impact the decisiorrmaking process leading to one or more of these ends,

A Review of the Options

With the reasonably obvious exception of single-well caisson type structures for which the abandonment of the well itself virtually mandates total structural removal, the issue of removal must address two basic parts of the platform.

Most of the above-water portion of a platform consists of what is known as the deck. Decks vary from minimum structural accommodation to protect and service wellheads to those of larger areas, which are designed to support wells, drilling rigs, production equipment, personnel living quarters or some combination thereof. Historically, it has been our company's practice to remove deck portions together with any associated facilities for transportation to a shore-based location. The available options downstream of this decision include either complete or partial reuse of deck, facilities, or both. These options are considered preferable to partial offshore dismantling (e.g., equipment removal) followed by cleanup, to render the remaining portion suitable for placement as reef substrate. The availability of used structural components and equipment can have considerable impact on the economical considerations of new petroleum production projects, as presented in the following case.

The available options that exist for the structure that remains after deck removal have altered slightly with recent reef site determinations, particularly those associated with Louisiana's Artificial Reef Program. Structures that exist within a designated reef platform area must certainly add some method of inplace/onsite disposal to the overall economic analysis. A paper by others at this conference will address the special considerations that this additional option demands.

The site-specific example that became the basis for this paper began with normal plans for platform decommissioning and removal from a former oil and gas production site offshore southwest Louisiana. A new option for reuse of the structures presented itself when Louisiana established an artificial-reef planning area several miles from our lease site. It should be noted that this paper does not address specifics associated with negotiations among the co-owners of the lease site regarding ultimate disposition of the structure. Such negotiations will be a critical step in converting rigs to reefs from many of the oil and gas leases in the Gulf of Mexico.

Project **Overview**

During 1974, exploratory drilling on West Cameron Block 513 (figure 1) confirmed seismic data on which earlier bid development assumptions had been based. The result of this drilling, as far as the platform structural considerations are concerned, was a decision by the company to develop the prospect using a platform concept known as the T.A.M.PA. (Tender Assisted Minimum Platform Arrangement) (figure 2). Basically, the concept uses two 4-pile platforms that are bridge-connected to facilitate safety and ease of operations during both drilling and production phases of the field development.

Both structures were installed complete with decks during 1975. The combined weight of both jackets (subsea support structure) together with piling, decks, bridge, and equipment was approximately 3,000 short tons (2,722 metric tons). From the point of view of this paper, the only activities of significance during the life of the platforms at West Cameron 513 were annual verification of the corrosion protection system and, unfortunately, a minor ship collision with one of the two structures.

The company's preferred system for corrosion protection in the Gulf of Mexico is the use of sacrificial anodes. This system consists of numerous anodes of approximately 450 lb (204.1 kg) welded to the underwater jacket members. Original designs call for 10 years of protection for the structural steel by controlled dissolution of the anode material. This protection can be monitored and verified by measurement of the electrical potential of the platform relative to the surrounding seawater. For the years these two platforms were in service at West Cameron 513, the surveys indicated good corrosion protection.

In 1980 a vessel from the ship channel that transits Block 513 collided with the production structure. Neither the ship nor the structure sustained catastrophic damage; however, the platform jacket was affected enough to preclude later relocation and reuse considerations for reasons that shall be detailed later.

(Note: To avoid possible misunderstanding, it should be pointed out that, following the incident with the ship, the platform was inspected and sufficient analysis was done to satisfy Amoco and the appropriate Federal agencies that the jacket was more than adequate for its continued use at West Cameron 513 "B" location. The concern that led to the decision not to reuse it was over the increased stresses associated with removal, etc., to which the jacket would not be subjected during normal USC.)

By late 1984 the volumes of gas and condensate being recovered from the reservoirs at West Cameron 513 were insufficient to warrant the continued operation of the platforms. Further, once the platforms were off production the company was bound by existing lease agreements with the Federal Government to remove the structures toa depth of 16 ft (5 m) below the sea floor. Because of the relatively short use that these structures had received and because of a company practice to investigate reuse possibilities, the West Cameron "B" T.A.M.P.A. pair became candidates for close scrutiny in regard to future utility.

The components of the T.A.M.P.A. arrangement that were available were the drilling jacket and associated deck; the production jacket with deck and facilities designed to handle daily throughput of 50 MMcfd; the bridge, which connected the two platforms; and the steel piling, which had been driven through the two jackets and into the sea floor. An evaluation ot each component was required to determine not only the economic but engineering feasibility of salvage and reuse.

Project Details and Analysis

The first of the platform components from West Cameron 513 "B reviewed for future utility were the easiest for which a decision could be made. Asstated earlier, theexisting company philosophy regarding decks and facilities made determining the reuse of the two decks the correct choice, virtually without detailed consideration.

There was a recognized need for the drilling deck to be used in the additional development of an existing oil and gas field. Since none of the other owners had an immediate need for the deck, it was purchased from the joint account. Tbedifferential between that cost and that of a newly fabricated deck worked to enhance the economics of the extended field development at the new location.

Although at the time there was not a known immediate need for the production deck and its associated 50 MMcfd facility, all of the companies involved agreed that the ultimate reuse potential was obvious. Without determining a current value or a future owner, the decision was made to transport the deck to shore after removal from the jacket for temporary storage. Atthetime ofthis writing, that deck is being modified structurally and the gas-handling facilities are being refurbished in preparation for reinstallation on another development project. That project and associated economics will not be detailed here, but the approximate savings after purchase from other working interest owners and revamping costs are in excess of $1.0 million as compared to a new deck and facility, The analysis of reuse potential for both of the decks may appear somewhat perfunctory. Indeed, once a current need that can be met by these used components is identified, the decision is obvious. The decks are the only portions of the structural arrangement as a whole that are this readily analyzed. Since they are above water and therefore easily inspected and maintained, their condition for reuse is more definable.

The remaining components would reply not so directly on philosophy as on engineering and economic feasibility for analysis of reuse potential. The engineering factors that were considered were water depth match, general structural condition and integrity, and soil and environmental conditions at the new site, compared with original design criteria. The details of these analyses will be discussed forther.

The economics associated with the possible use of the jacket, even if it were suitable technically, are highly dependent on a number of factors. Anticipated fabrication and offshore installation costs for 1986 were to be low enough to make careful comparison necessary. Estimates of the costs for a newly fabricated jacket were made and compared with anticipated costs for moving the existing jacket. The differential of $500,000 was determined to be enough to warrant taking the necessary risks associated with a salvage and reinstallation project.

The engineering feasibility portion of the analysis for the production jacket was, for reason of a ship collision mentioned earlier, more or less simplified. The call, made by Amoco's technical experts, was that the level of uncertainty associated with the damaged jacket would require an unacceptable amount of inspection work to determine the inplace condition. Even with that basic information, a similarly economically unattractive degree of detailed engineering analysis would be needed to determine whether or not the jacket would withstand the stresses of removal, transportation, and reinstallation. It was agreed that, by the time the engineering had been carried out and some probable modifications done to allow reuse, any savings from using the structure would likely have been eliminated.

The balance of the decision process for this jacket was one of economics. Due to the provisions of Rigs-to-Reef legislation that had been developed at the time, there was no option to leave the platform at the original location. Further, had there been available an option such as inplace toppling, it is unlikely that this jacket would have received approval because of its proximity to shipping lanes.

Once the jacket was disconnected from the seabed, only two real options were available. One was transportation to a shore location, followed by offloading and disposal as scrap. The alternative was transportation to an artificial reef site and offloading/placement as reef substrate material. Unfortunately for the reef development option, the nearest site for which we anticipated obtaining a permit was too far away to be economical. The cost of taking the jacket to shore for scrap was $162,000, compared to the $279,000 to transport it to the available reef site. The additional cost included, of necessity, some method of offloading the jacket at the reef location. The selected method for cost comparison was use of a derrick barge such as was required to place the jacket on a barge for transport. Other options were reviewed but were more expensive.

All additional costs to go ahead with the reef option would had to have been borne by Amoco and partners. The economics for that type of operation are considered in terms of least cost liabilities as opposed to return on investment or payout. Consequently, a significant difference between the costs of the alternatives usually results in selection based on lowest numbers.

The remaining significant component evaluated during this project was the jacket portion of the drilling platform. The water depth at the West Cameron 513 location was 173 ft (52.7 m) and at the new location 183 ft (55.8 m). The structural modifications required to accommodate this difference consisted of removing and lowering the boat landing and barge bumpers. The costs associated with this work were detailed and used in the reuse analysis,

Divers were employed to verify the basic structural integrity of the jacket. This work did not consist of detailed cleaning off of marine growth followed by nondestructive weld inspection. Since there had not been any specific incidental damage such as caused by vessel collision, this effort could take the form of visual inspection. The divers confirmed that the structure was basically in the original, installed configuration. This inspection, coupled with the historical data discussed earlier indicating adequate cathodic protection during the time at West Cameron 513, served as adequate evidence that the drilling jacket was basically sound.

The next step in the determination of reusability dealt with analysis of conditions that would affect the structure's ability to exist for the required amount of time at a new location. Environmental data for wind, waves, and currents associated with both normal and worst-case storm conditions were calculated. These were combined with data from a geotechnical investigation to determine not only the forces that the jacket would have to withstand, but also the optimum design of both wall thickness and seafloor penetration for the piling, which would be driven through the jacket, to allow those forces to be endured.

In addition to the inplace analysis that was performed, there were certain considerations associated with the removal, transportation, and reinstallation activities for which forces had to be calculated. There is a significant sequential or domino effect caused by assumptions made in these areas. Both company and outside consultant experts were concerned that the stresses associated with rotating the jacket to a horizontal position and placing it on a cargo barge for transportation prior to reinstallation could be detrimental. Rather than go through the iterative analysis that would be required to determine if the structure could be handled in that manner without modification, a decision was made to limit removal and transportation to handling the jacket only in the vertical position. This decision was limiting in itself in that the height of the jacket (approx. 195 ft [59 m]), combined with its approximate weight of 600 short tons (544 metric tons), would allow only certain vessel/crane combinations to perform the work.

In order to be able to set the jacket on the seafloor at the new location during the reinstallation sequence, the designers had to account for mud line conditions. Experience in the new site area, coupled with the soil boring results, concluded that mud mats, or large horizontal areas at the bottom of the jacket, would have to be able to support the structure on the soft bottom. The design to replace the original mud mats had to take into account a method for reinstalling the structure offshore. After input from various sources, a decision was made to prefabricate the new mud mats and have them on the deck of the derrick barge. Once the jacket was on the crane's hook, and minor preparation was done to the bottom of the jacket legs, the jacket could beset onto the mud mat assembly and the modifications completed while the barge was underway to the new location.

The remaining portion of the platforms that has not been discussed is the piling. For planning purposes regarding reinstallation of the salvaged jacket, it was determined that offshore modification/refurbishment of the piling material would be uneconomical. Appropriate design and fabrication work were carried out, and new piling was installed at the new site.

The removal of the piling from the drilling jacket was accomplished with no significant problem. Three of the four production platform piles easily came free of that jacket also. The final pile would not pull out of the jacket and was left in the jacket leg for transportation to the scrapping location.

The condition of the salvaged piling was such that the material was stored for future use. As of this writing some of the material has been reused in the further development of a field in offshore Texas.

Summary

This particular project, due to the platform arrangement and specifics for each jacket, allowed a review of mainly the economic aspects of options available in salvage situations, with the exception of abandonment inplace. Decisions must be made regarding each of the various components, and each decision must include both technical and economic considerations. The combination of technical feasibility and economic attractiveness must work together to allow reuse of components.

Unfortunately, for this particular case, the cost of logistics associated with the reef option was too high to make that choice economically viable. The establishment of multiple areas in the Gulf of Mexico as artificial reef sites will work to enhance the attractiveness of that option for future projects involving components determined not to have reuse potential.

Many issues that impact the decommissioning phase of petroleum activities in the Gulf of Mexico are interrelated. Changes such as Rigs-to-Reefs options and an increased understanding of the environmental and legal considerations serve to enhance the economics of abandonment and should allow continued development of platform-related artificial reefs.

Mr. John Gilmore is a graduate of Florida Atlantic University with a B.S.O.E. He was reared in a military family and has been in the oil business for the past 14 years and, as a result, is somewhat of a gypsy. Since joining Amoco in 1973, he has lived in Louisiana twice, in Chicago, Cairo, and London, and now in Houston. Most of his career has been involved in project engineering or management of offshore structures, equipment, and pipelines, and several onshore oil and gas related projects. He is involved with two projects for the Gulf of Mexico, one with all-new structural components and one that will use a deck that was salvaged during the operation about which this paper was written.

General Location Map - West Cameron Block 513

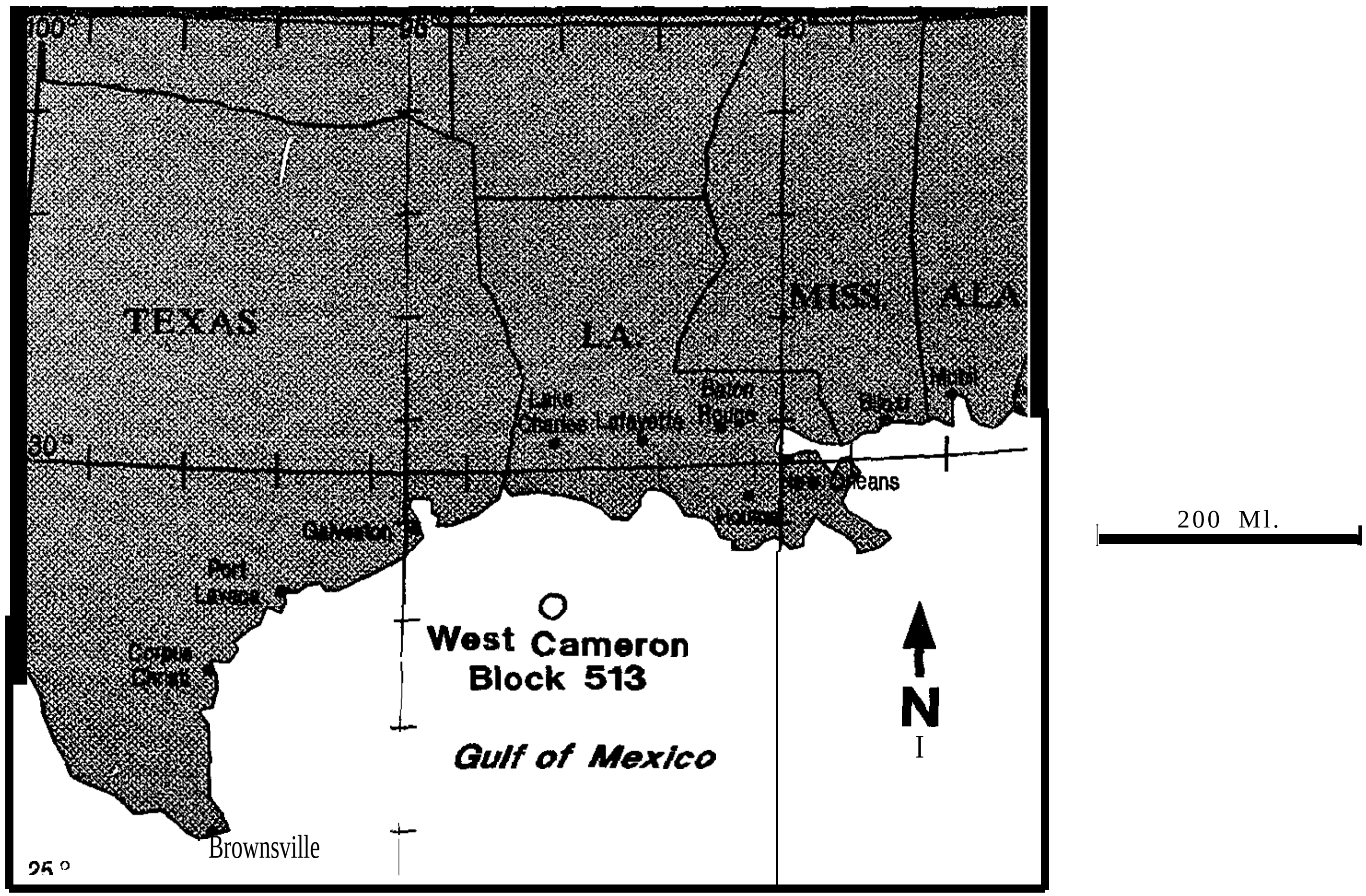


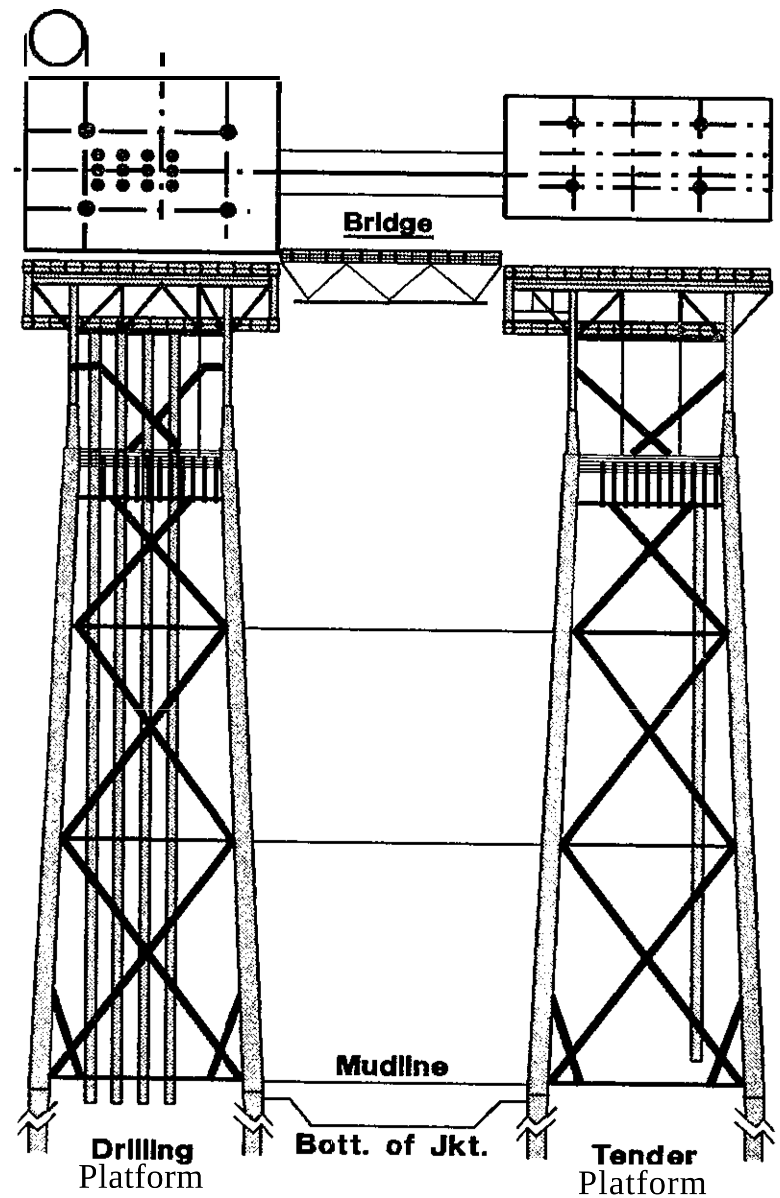
FIGURE 1

AS SUBMITTED BY AUTHOR

Figure 2

T.A.M.P.A.

(Tender Assisted Minimum
Platform Arrangement)



AS SUBMITTED BY AUTHOR

Rigs-to-Reefs–A Case History

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The conversion of abandoned offshore platforms into artificial reefs has been done previously with little cost savings and often at considerable added expense to the lessees for transportation to an approved reef site. Efforts to obtain these structures for artificial reefs have predominantly been made by the State of Florida while the majority of offshore platforms are located in the Gulf of Mexico off the Louisiana and Texas coasts. Furthermore, shallow water structures in less than lOOft (30.5 m) of water are often the earliest structures installed and the first to deplete their hydrocarbon resources, necessitating their removal. The cost for shallow water removals is generally less than that in deep water and it has been cheaper m haul them to shore for scrap rather than cut them up and transport the materials to a permitted reef site.

Recent efforts by Louisiana have brought reef areas closer to deep-water platforms, thus reducing much of the added logistical expense in reef construction. This paper describes the engineering planning, permitting, and actual field work performed to convert a production platform 90 miles (145 km) offshore Louisiana into an artificial reef under the Louisiana Artificial Reef Program. The project involved variances from regulatory requirements and normal structure removal procedures resulting in cost savings to the lessees and income to the Louisiana Artificial Reef Program, basic necessities for a self-sustaining extensive effort to utilize offshore structures for artificial reefs.

Summary

Research has shown that offshore petroleum production platforms serve as prime artificial reef habitats for marine organisms and are popular target fishing areas (Gallaway and Lewbel, 1982). In the Gulf of Mexico, the thousands of offshore structures provide a significant portion of the hard substrate in a naturally soft-bottomed environment (Gallaway, 1984). Regulatory requirements mandate the removal of obsolete hydrocarbon production structures. Unfortunately for marine habitat, it has been the standard practice to remove these structures and haul them ashore.

Several isolated abandonments in recent years have involved moving portions of offshore structures to reef sites off Florida and Alabama. These cases were at best "break-even" economic alternatives to traditional scrapping, and sometimes added considerable costs over normal structure removal. Understandably, this type of structure removal and disposition does not provide the economic incentives or tax benefits for creating reefs.

In October 1987, the Louisiana Artificial Reef Program (LARP) became operational when the first production platform was donated by OXY USA Inc. (OXY), known then as Cities Service Oil and Gas Corporation. Since tbe structure was located within one of the program's eight designated reef areas, it was possible m "topple" the jacket and conductors in place. The resulting cost savings over a traditional salvage were shared with the Louisiana Artificial Reef Program.

Background

The South Marsh Island Block 146 Platform was an 8-pile drilling and production platform designed with 18 well slots, a standard packaged API drilling rig and production equipment for 60 million standard cubic feet daily gas (MMcfd) production (figure 1). The platform was installed in 1977 and supported 9 conductors; it was located approximately 90 mi (145 km) southwest of Morgan City, Louisiana, in 237.6 ft (72 m) of water.

The concept of Rigs-to-Reefs is not new. For many years, fishermen and divers have congregated around Gulf of Mexico offshore structures where they found better fishing anddiving (Dittonand Auyong, 1984). The structures have been taken for granted in Louisiana and Texas where there are several thousand inplace. Florida recognized the excellent reef potential afforded by these structures and made known its desire to obtain obsolete structures to add to its extensive artificial reef program (Barrett, 1984). An Exxon subsea production template (1980) and Tenneco structures (1982, 1985) were towed to locations off of Florida, and a Marathon structure (1983) was moved to a siteoffshore Alabama (Reggio,1987). All of these efforts required costly towing to distant sites where reef programs were in effect. Generally, these projects were driven by goodwill or as a demonstration for tax incentive legislation, Economic factors would have suggested the structures should be hauled ashore for scrap.

In 1984, the National Fishing Enhancement Act (Title II of P.L. 98-623) was passed, designed to ensure the responsible and effective construction of artificial reefs in the United States waters. The Act specified national standards, provided for a National Artificial Reef Plan (U.S. Dept. of Commerce, NMFS, 1985) and addresses the liability of a reef permittee and reef material donors.

Shortly afterwards, the Louisiana Artificial Reef Initiative (LARI) was commenced to respond to concerns that the State's "reef' system of petroleum structures would be disappearing at an alarming rate. Legislation for the Louisiana Artificial Reef Development Program (Act 100) was passed in June 1986, and the site selection process for the first eight reef planning areas was finalized approximately one year later (Wilson, Van Sickle, and Pope, 1987).

Initial reef areas established under the LARI program were located in water depths greater than 150 ft (45 m). Structures in these water depths offer a better likelihood of an operator realizing cost savings utilizing a reef option over onshore scrapping. It is also possible in these water depths to achieve sufficient navigational clearance with normal dismantling techniques and minimize navigational aids maintenance costs. Reefs in shallower water, while they may be more accessible to recreational fishermen, will generally be at a cost disadvantage when compared to hauling materials to shore for scrap. Suggested methods tooffset this cost differential include (1) creating tax incentives (as providedin the National Artificial Reef Plan) in return for the value of the artificial reef material being donated, (2) paying for reef materials by the artificial reef program, and (3) developing a program in which an oil company allows cost savings for deep water salvage(s) to offset the increased costs for shallow water salvage(s).

When it became apparent that the structure on South Marsh Island 146 would be of no further use for petroleum production, efforts began with the State of Louisiana to have it included within one of the planned reef areas. The proposed area survived the site selection process, and work began in satisfying legal and regulatory concerns. Innovative engineering alternatives would be developed to identify the most cost-effective methods of platform decommissioning,

Legal Considerations

Areviewof the Operating Agreement was made to ensure all activities were properly authorized. It was decided that a letter would be sent to joint-interest owners of the platform notifying them of plans for the reef creation. No concerns were voiced by the partners.

The next task of great importance to OXY was development of the deed of donation for the Louisiana Artificial Reef Program. Both the title transfer and the monetary donation would be made apart of the package. The structure's distance from shore and approximately 125 ft (38 m) of navigational clearance keep liability concerns at a minimum. However, as a model for future reef projects, the format for the deed of donation needed to adequately relieve donor companies from these uncertainties. This was accomplished to the satisfaction of both parties a couple of weeks prior to salvage operations.

Regulatory Considerations

The Louisiana Artificial Reef Program, within the Department of Wildlife and Fisheries, submitted a permit to the Corps of Engineers to establish the reef area around the South Marsh Island 146 "A" platform, which was located within one of the planned reef areas. The careful planning done in the Louisiana program produced no adverse public expressions during the comment period.

OXY had worked closely with the Minerals Management Service (MMS) in their Rigs-to-Reefs efforts overthe pastyears. Inorder to provide for the on-site abandonment, the MMS requirements for site clearance in both the lease agreement and OCS Order Number 3 (U.S. Dept. of the Interior, Geological Survey, 1980) would have to bewailed. A request for departure from these requirements was approved by the MMS Gulf of Mexico Region office contingent upon participating in the Louisiana program under a Corps of Engineers permit. While plans were tosever the piles 16 ft(5m) below the mud line, the MMS on-site observers would be able to allow for a departure to a lesser depth should unforeseen difficulties been-countered during the salvage operations. Other MMS requirements concerning the plugging and abandonment of wells had been accomplished prior to the proposed operations.

The decision to utilize explosives was made atanearly stage in planning. Explosives are the safest, most reliable, and cost effective method of severing the piles and conductors below the mudline. In 1986, concerns regarding the safety of five species of endangered or threatened sea turtles brought explosives use for platform removals under careful review. Although there was little knowledge regarding sea turtles and their association with offshore platforms, the MMS began requesting information from operators prior to platform removals. If explosives were to be used, the MMS determined that it''may affect'' endangered species and initiated a consultation with the National Marine Fisheries Service (NMFS) based on Section 7 of the Endangered Species Act of 1973. The NMFS evaluated each situation and provided an Incidental Take Statement that protected an operator from penalties under the Endangered Species Actif they incidentally "took" a sea turtle, provided conditions specified in the statement were followed.

Prior structure removals had included NMFS and MMS observers, and almost all had limited explosives operations to a period somewhat shorter than daylight hours. OXY voiced its objections to this and requested round-the-clock operations based on (1) the unlikelihood of turtles in 237.6 ft (72 m) water depth and this distance from shore; (2) the extremely high fixed costs associated with marine operations; (3) the high risk and cost of encountering weather standby time while being shut down waiting on daylight; and (4) the "ultimate" mitigation measures being taken through the creation of a permanent marine reef habitat. Discussions with the MMS and NMFS were productive and the Incidental Take Statement provided for 24-hour operations if no "resident" turtles were observed during a specified observation period prior to the detonations. The statement still required observations during daylight hours to locate and remove transient turtles.

Because of the lack of additional knowledge, observation is at present the only scientific way to determine the presence or absence of turtles at a platform. It is hoped that the "resident" turtle concept can be extended to other platform removals, allowing around-the-clock operations.

Observations and removal tactics for marine mammals (primarily dolphins) were to be included as mitigative measures. The Marine Mammal Protection Act of 1972 protects these animals. The Incidental Take Statement under the Endangered Species Act did not cover marine mammals; however, the NMFS personnel could authorize the use of "scare" charges to encourage tbe animals to leave. A "permit" under the Marine Mammal Protection Act to "take" animals would be a lengthy regulatory effort. Dolphins, however, are more easily located, and it was felt that they could be successfully moved away from the site if any were seen prior to detonating explosives.

Engineering Considerations

OXY'S initial engineering activities evaluated the potential platform abandonment options to select the optimum method of exploring opportunities provided by the Louisiana Artificial Reef Program. Options available for constructing artificial reefs are as follows (Reggio, 1987):

1. Abandon structure in place
2. Partially remove structure
3. Topple structure on location
4. Removal and relocate structure

After the alternatives and current available technologies were considered, it was determined that the logical and most economical method of decommissioning the South Marsh Island 146 structure would be to topple it in place, The deck section and equipment would be removed for reuse and to allow access to the piles for setting charges.

Engineering analyses that needed to be done included the following:

1. Establish the magnitude of the pulling load necessary to topple the jacket.
2. Establish the structural capacity of the platform to ensure design capacities would not be exceeded by the pulling load.

3. Establish the foundation capacity of the mudline framing to determine its ability to withstand toppling stress.

4. Physically inspect the platform to verify its integrity relative to design capacities.

5. Establish a method to sever piles and conductors that would guarantee severance while minimizing the amounts of explosives to diminish effects on marine life.

6. Plan salvage sequence that can be performed with marine equipment currently available in the Gulf of Mexico.

Salvage Operations

In late September, a crew was placed on the platform to perform preparatory cleaning and dismantling work. This minimized costly derrick barge time during salvage operations. At the same time, a team of divers performed an underwater inspection of the jacket to verify its integrity. Due to the water depth and size of the jacket, the inspection took two days.

On October 25, 1987, the crane ship *Ocean Builder 1* was positioned alongside the South Marsh Island 146 "A structure. The 9 conductor strings were each severed 16.4ft (5 m) below the mudline utilizing 30 lbs (13.6 kg) of Comp "B" explosives in a double detonated configuration. The charges were specifically engineered to minimize the amount of explosives required, but were sized sufficiently to ensure that the multiple pipe strings in each conductor were severed completely on the first attempt. Operations were carried on from the platform as each conductor was shot separately with an average 20-minute delay between firings. The impact of these charges was small enough to allow certain other work tasks to be performed concurrently with the severing of the conductors.

Next, the quarters building and production equipment skids were removed from the deck and placed on the cargo barge. The deck legs were than severed below the existing stabbing guides so the l,250-short-ton (1,134-metric-ton) deck could be removed. After the deck had been removed and sea-fastened on the cargo barge, the barge and tug were sent to shore. OXY will reuse the production equipment and quarters. The deck has been sold to another company for reuse.

Previous literature has indicated that reuse was not an economic alternative. Present conditions such as low oil and natural gas prices, idle salvage yards, and the many small companies entering the offshore exploration and production business have made reuse a viable alternative to onshore scrapping or reef creation.

With the jacket protruding approximately 16.4 ft (5 m) above the water surface and the conductors another 39.4 ft (12 m) higher, the next task was to sever the structure's piles. The eight 48-inch (outer diameter) by 2-inch (121.9 cm by 5.08 cm) W. T. piles were each cut by utilizing 50 lbs (22.7 kg) of Comp "B in a "configured" charge placed 16.4 ft (5 m) below the mudline. The charges were staggered to eliminate cumulative effects of the explosions on marine life. The piles were successfully severed, evidenced by the jacket sinking several feet.

Next, cap plates were welded on the piles and the water was blown out to minimize both the on-bottom weight and the corresponding pulling load necessary for toppling. Four derrick barge anchor cables were attached to the jacket and the barge was positioned approximately 800 ft (244 m) from the jacket (figure 2). After pulling a constant 350 short tons (318 metric tons) on the anchor winches for about 60 minutes, the mud suction at the base of the platform broke, and the 3,500 short-ton (3, 175 metric-ton) jacket, conductors, and piles (figure 3) toppled.

Results

The permanent high profile benthic reef created is quite impressive (figure 4). The South Marsh Island 146 reef has over 1.4 hectares (3.5 acres) of hard substrate surface, and it encloses over 3.3 million ft^3 (93,400 m^3) of volume. The mudline plan is more than 41,964 ft^2 (3,900 m^2), which is better than twice the footprint of the original configuration.

The reef is stable. It has a calculated safety factor of 10 against sliding due to forces from 100-year-design wave and current. The reef will also have along life. Assuming a 15-year life remaining on the existing anodes and utilizing the average corrosion rate of steel immersed in saltwater, we can conservatively expect a life approaching three centuries.

Fish mortality due to the explosives was minimal. Approximately 75 fish floated to the surface. Red snapper (*Lutjanus campechanus*), vermilion snapper (*Rhomboplites aurorubens*), sand seat ro u t (*Cynoscion arenarius*), reef but terflyfish (*Chaetodon sedentarius*), and black grouper (*Mycteroperca microlepis*) accounted for over 40 percent of the species recovered. Divers also found a small number of fish on the bottom. A posttoppling dive and video survey conducted by the same dive team that had done the diving one month earlier indicated fish levels approaching those prior to salvage operations.

'l'he Louisiana Artificial Reef Program shared in the cost savings realized by OXY. The monetary donation made by OXY to the program will be used to offset administrative, legal, buoying, and maintenance expenses associated with the reef site. This money and future monies collected by the program may also be used to subsidize costs of developing shallow water reefs where the construction and/or maintenance costs exceed normal salvage costs. Hopefully, monetary donations will enable the Louisiana Program to be a self-sustaining, “full service” reef program that combines the needs of nearsbore recreational fishermen and offshore commercial fishermen and effectively utilizes these materials of opportunity from tbe oil and gas industry.

Acknowledgments

The authors would like to recognize the cooperation and support of OXY USA Inc. (formerly Cities Service Oil and Gas Corporation), the Minerals Management Service, and the National Marine Fisheries Service in the successful accomplishment of the project.

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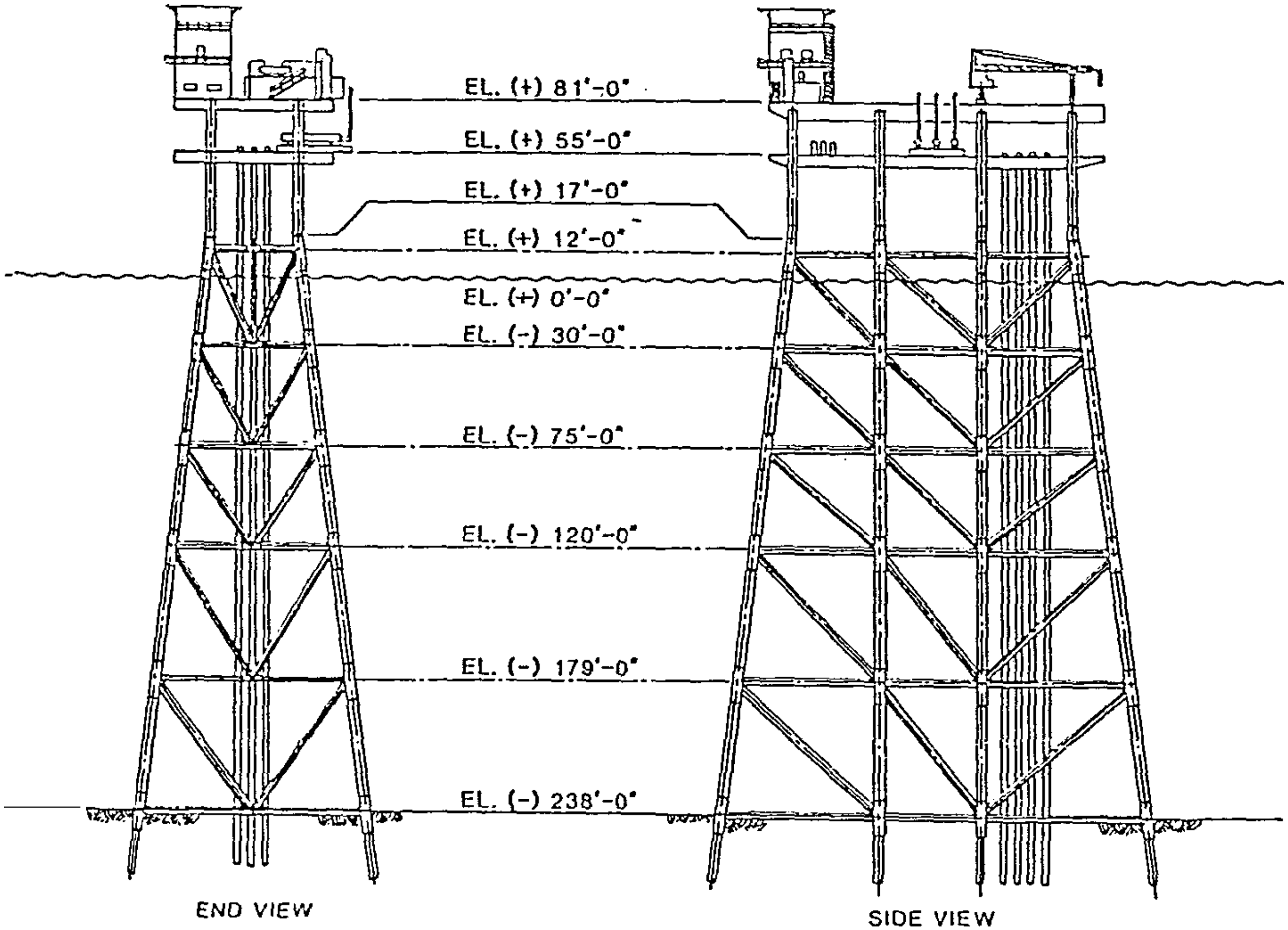

Fig. 1 - Platform Configuration

AS SUBMITTED BY AUTHOR

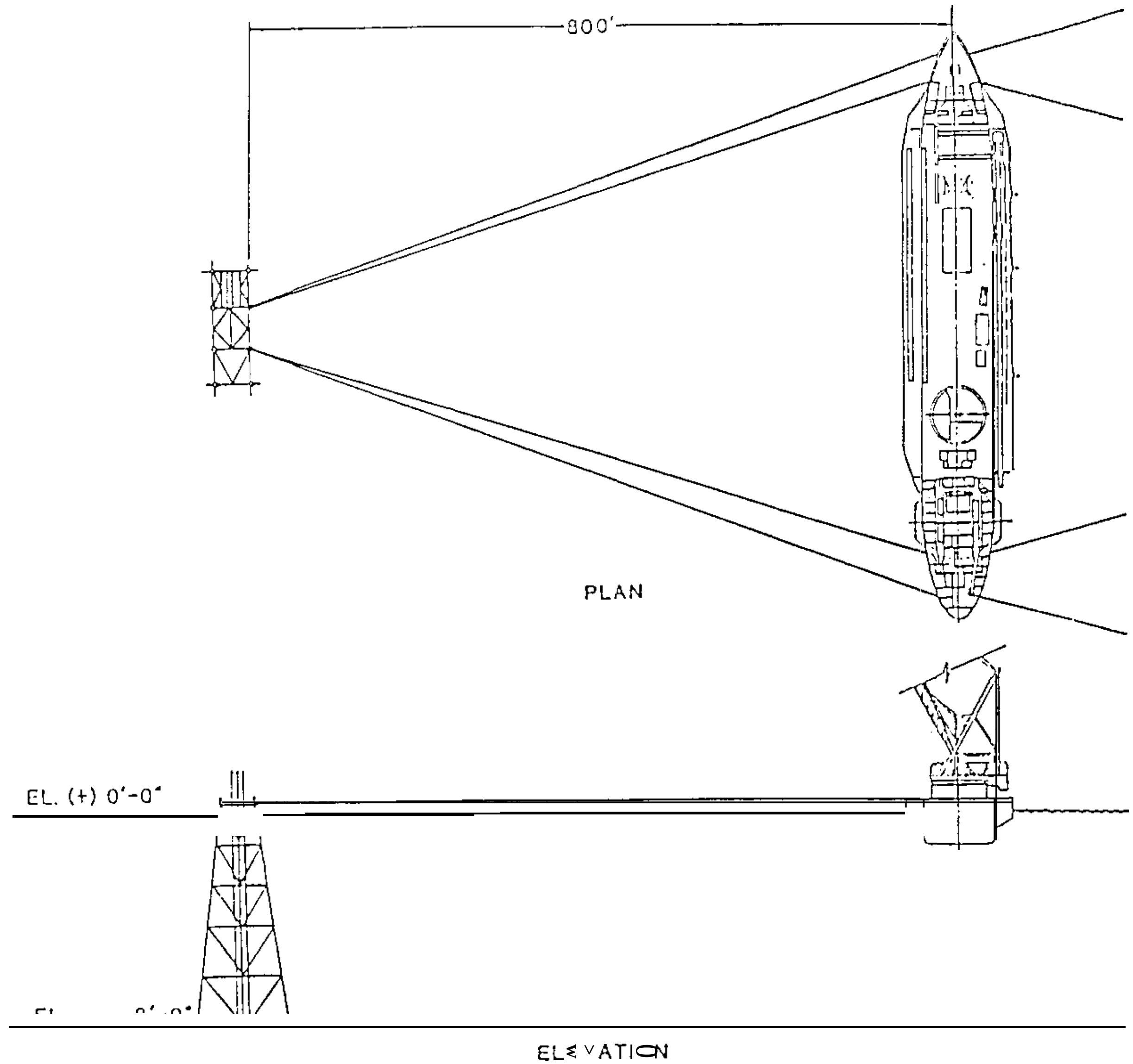

Fig. 2 - Rig up to jacket for toppling
AS SUBMITTED BY AUTHOR

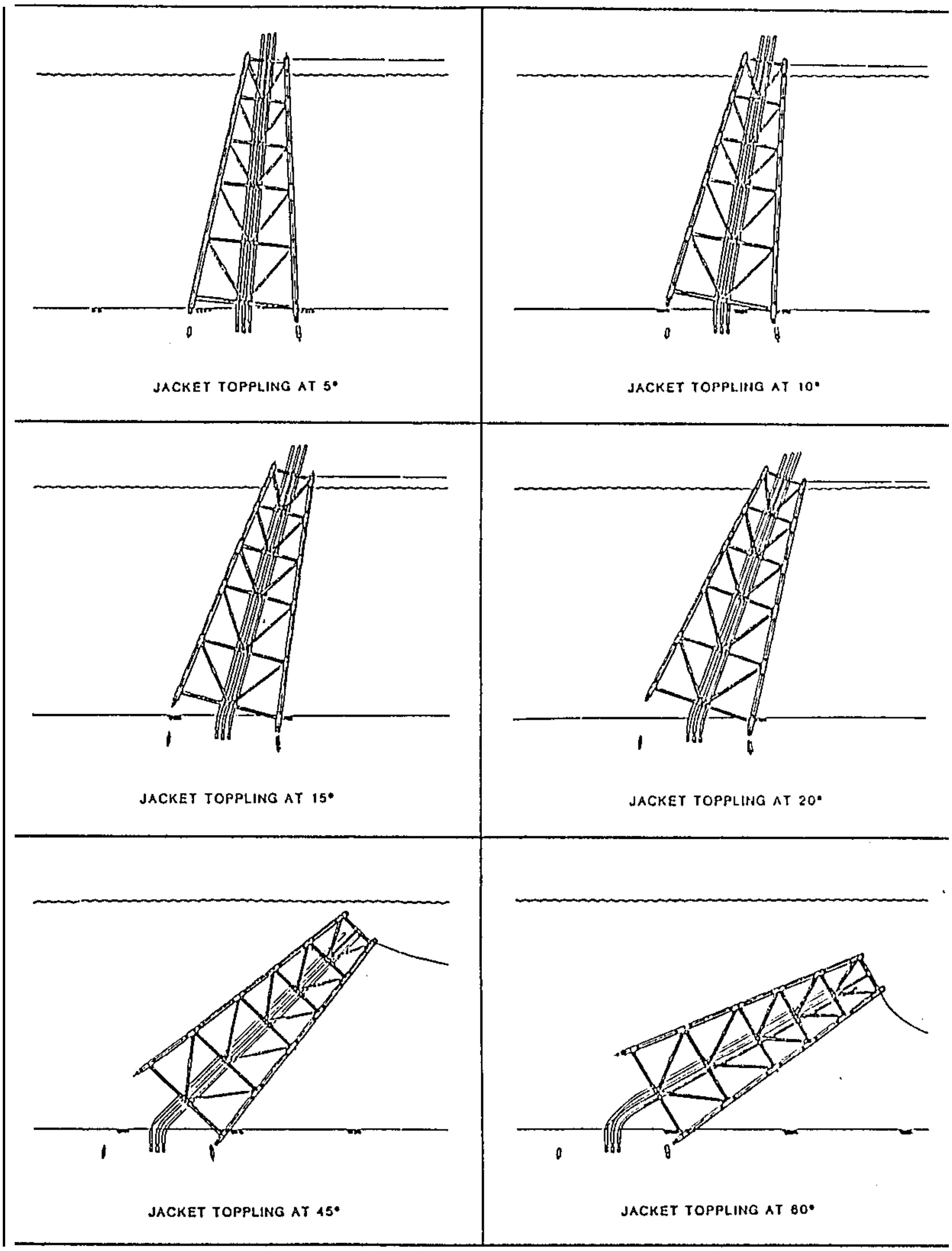

Fig. 3 - Jacket toppling sequence

AS SUBMITTED BY AUTHOR

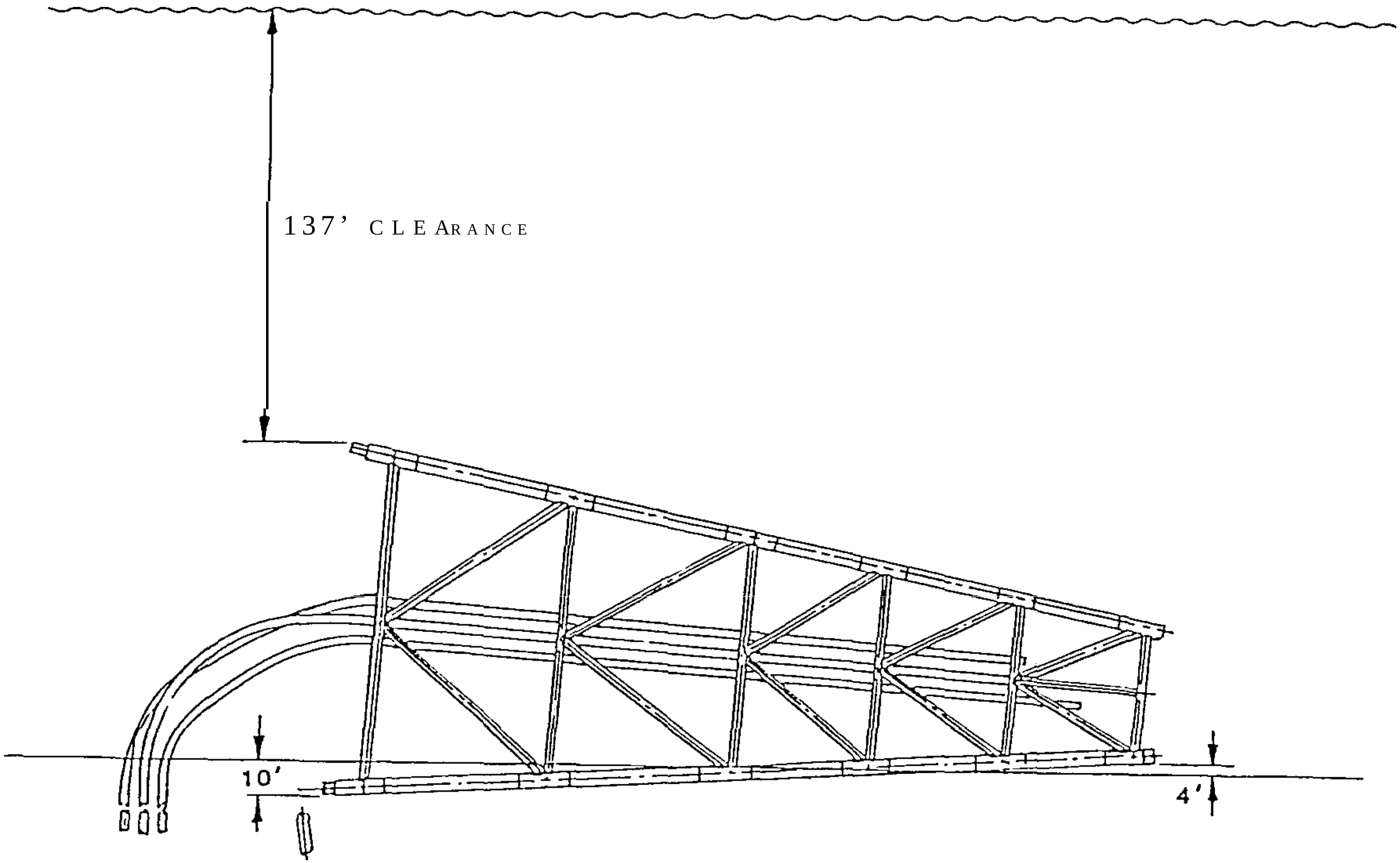

Fig. 4 - View **of** toppled **jacket**

AS SUBMITTED BY AUTHOR

Impacts of the Explosive Removal of Offshore Petroleum Platforms on Turtles and Dolphins

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Abstract

Strandings of 51 dead sea turtles (primarily *Lepidochelys kempi*), 40 dolphins (primarily *Tursiops truncatus*), and many fish were recorded on beaches in the northwestern Gulf of Mexico from March 19 to April 19, 1986. During this period explosives were used to remove several oil platforms in adjacent offshore waters. Drift bottles released at the site of one of the explosions were recovered with some of the strandings. Shrimp fishing activity, a known cause of turtle mortality, was at a normal seasonal low. Circumstantial evidence suggests that at least some of the strandings of marine animals may have been due to underwater explosions used in removal of oil platforms.

A total of 6 turtles was observed at 3 of 11 removal sites during March 1986 through September 1987, and a maximum of 26 dolphins was observed at each of 10 sites. One wild sea turtle was observed sinking after an explosion, but it could not be recovered to document its injuries. Necropsy of one stranded loggerhead turtle found two days after a 1987 removal showed hemorrhaging of the lungs, which is consistent with impacts of an explosion; this condition may also be attributed to postmortem decomposition of tissue. In a preliminary experiment, two of four Kemp's ridley and three of four loggerhead (*Caretta caretta*) turtles were rendered unconscious after placement within 3,002 ft (915 m) of the simultaneous explosion of four 50.7-lb (23-kg) charges.

Comparison of turtle strandings during periods characterized by high and low numbers of offshore explosions (March-April 1986 and March-April 1987, respectively) suggested a positive relationship between the frequency of explosions and the stranding of turtles. Although dolphins may be impacted by explosions, the relationship between the stranding of dolphins and offshore explosions was not as conspicuous.

Introduction

Between March 19 and April 19, 1986, 51 dead sea turtles, primarily the endangered Kemp's ridley (*Lepidochelys kempi*), were found on beaches of the upper Texas coast. Ten petroleum structures were removed from this area when shrimping activity, a factor contributing to turtle mortality (Henwood and Stuntz, 1987), was at a seasonal low (figure 1).

During the summer of 1986 the Minerals Management Service (MMS) and the National Marine Fisheries Service (NMFS) discussed the effects of offshore explosions on endangered and threatened sea turtles. They agreed to hold formal consultations, as provided under Section 7 of the Endangered Species Act of 1973, for each proposed use of explosives in Outer Continental Shelf (OCS) waters of the Gulf of Mexico. Beginning in 1987, companies planning to remove oil and gas structures (platforms, caissons, well conductors, flare stacks, etc.) with explosives were required to obtain a permit from MMS. Permits authorized the use of explosives, provided the company followed certain requirements, which generally included the following: (1) visual monitoring for turtles around the removal site by observers approved by NMFS and operating from the work platform and frequently from helicopters, (2) pre- and postblast diver surveys for sea turtles, (3) delaying detonations to allow observed turtles to leave the area, (4) detonating only during daylight hours to facilitate visual monitoring, and (5) staggering detonations to reduce the maximum pressure generated by the explosions.

High-velocity explosives are typically used to sever pilings and conductors 16.4 ft (5 m) below the mudline during removal operations. A crane then lifts these structures out of the water to a barge for return to shore. It is important to assess the potential impacts of these activities on sea turtles and other marine life. The MMS estimates that there were 3,435 platforms in the Federal OCS as of December 1986 and predicts between 60 and 120 structures will be removed annually for the next five years. The National Research Council (1985) estimates approximately 1,700 structures will be scheduled for removal between 1984 and 2000. The Council predicts about 100 to 130 removals annually between 1990 and 2000.

This paper reports on (1) the relationship of explosive events with strandings of sea turtles and dolphins, (2) biological monitoring at 11 structure removal sites during April 1986 through September 1987, and (3) an experiment in which sea turtles were exposed to underwater explosions associated with the removal of a platform. Information pertaining to the association of turtles with offshore structures and the impacts of underwater explosions on turtles and dolphins is also discussed.

Materials and Methods

Sea *Turtle Stranding Network*

Since 1980, a sea turtle stranding network, operating primarily on a volunteer basis, has collected data from the U.S. Gulf of Mexico and Atlantic coasts. All information is centralized at the NMFS Miami Laboratory. The NMFS Sea Turtle Stranding Network has been documenting beach strandings of turtles along the Texas and western Louisiana coasts through routinely scheduled surveys since the spring of 1986. Prior to this, NMFS surveyed the beach only in response to strandings reported by the public. Organizations supporting this network include the University of Texas Marine Science Center, McNeese State University, Louisiana Department of Wildlife and Fisheries, and the U.S. Fish and Wildlife Service.

Both the area and frequency of coverage have increased tremendously since inception of the program. Nearly all U.S. beaches along the Gulf of Mexico west of the Mermentau River, Louisiana, are surveyed biweekly if accessible by pickup truck, motorcycle, or all-terrain vehicle. Some estuarine and remote island shorelines have been included in the survey area. To assess the effects of explosions more accurately, surveys along the coastline were generally intensified near inshore platform removal sites both immediately prior to and immediately following scheduled structure removal (figure 2).

Marine Mammal Stranding Network

The National Marine Mammal Stranding Network operates primarily on a volunteer basis and responds to calls from the public. Organizers in various states report strandings to a central office in Orlando, Florida. Data in this paper were supplied by the Texas Marine Mammal Stranding Network, College of Veterinary Medicine, Texas A&M University. Information gathered through the NMFS Sea Turtle Stranding Network has assisted in the acquisition of data on marine mammal strandings.

NMFS Monitoring of Platform and Caisson Removals

Observers monitored the area around structure removal sites prior to, during, and after detonation of explosives (figure 3, table 1). Preblast monitoring for sea turtles was conducted from (1) work and/or materials barges, (2) the structure being removed, (3) tug boats or crew boats as available, and (4) helicopters, if required in the Section 7 consultation authorized by the Endangered Species Act. Observers used helicopters to survey around the removal site to a distance of 0.9 mi (1.5 km). Thirty-minute flights were made within 1 h prior to and immediately following the detonations. Detonations were delayed 1 h if sea turtles or marine mammals were observed within 3,002 ft (915 m) of the detonation site, and the survey was repeated, unless there was verification that the animals had moved beyond the 3,002-ft range. Oil company divers made preblast dives around the structures to document the presence of sea turtles, marine mammals, and fish.

In all but one case, explosives were detonated no earlier than 1 h after sunrise nor later than 1 h before sunset. Following the detonations, dead or injured marine life were sampled on the bottom by divers and on the surface by personnel operating from a vessel. Observers in helicopters assisted this effort by communicating their observations to personnel collecting the animals. Fish were measured and identified. Drift cards were released at the removal sites in an attempt to document surface currents and to assist in correlating the location of strandings with offshore explosions.

Exposure of Turtles to an Underwater Explosion

An experiment was designed to provide preliminary information on the extent of the impact zone created by the explosive removal of an offshore platform. Kemp's ridleys weighing 1.3,2.9,3.3, and 14.8 lb (0.6, 1.3, 1.5, and 6.7 kg) and loggerhead turtles weighing 8.8, 9.3, 12.1, and 15.0 lb (4.0, 4.2, 5.5, and 6.8 kg) were placed in plastic mesh, steel framed cages 3.0 ft by 3.0 ft by 3.9 ft (0.9 m by 0.9 m by 1.2 m), one turtle of each species at four distances--750; 1,200; 1,800; and 3,000 ft (229 m, 366 m, 549 m, and 915 m). Turtles were unrestrained and allowed to swim freely in the cages. All turtles had deformed flippers but were otherwise healthy, and all were permanent residents of the NMFS, Southeast Fisheries Center, Galveston Laboratory. The cages were submerged to a depth of 14.8 ft (4.5 m) over the 29.5-ft (9-m) deep sea bottom, just prior to the simultaneous explosion of four 50.7-lb (23-kg) charges of nitromethane placed inside the platform pilings at a depth of 16.4 ft (5 m) below the mudline. The energy level of the shock wave generated by the explosion was estimated by Cummings for each of the four distances. Immediately following the explosion, turtles were retrieved and inspected carefully for external damage. Seabed drifters and drift bottles were released to define prevailing currents that might carry injured or dead marine animals ashore. All animals were transferred to the NMFS Galveston Laboratory and examined daily for the next month. The experiments were undertaken with the permission of the U.S. Fish and Wildlife Service under Permit No. PRT-676379.

Shrimp Fleet Fishing Effort

Detailed catch statistics for the U.S. Gulf of Mexico shrimp fishery have been compiled since 1956, and the procedures used *to col*lect them are described by Klima (1980),

Results

Relationship of Explosive Events with Strandings of Marine Life

A series of at least *22* explosions occurred between March 19 and April 5,1986, in conjunction with oil field structure removals within 4.4-6.8 mi (7-11 km) of the Bolivar Peninsula, near Galveston, Texas (table 2). During this period and the following two weeks, 51 dead turtles were found on beaches in Statistical Area 18, which includes Bolivar Peninsula and Galveston Island (figure 4). Of the 51 turtles stranded, 25 (49 percent) were reported within an 6.8-mi (1 1-km) radius and 44 (86 percent) within a 33.6-mi (54-km) radius of the structures that were removed. Forty-one dolphins (*Tursiops truncatus*), 15 of which were apparently smaller than the usual size at birth (i.e., fetuses ≤ 47.2 inches [120 cm] total length), also stranded (figure 4). After two detonations (370.4 lb [168 kg of explosive]) on April 5 , sheepshead (*Archosargus probatocephalus*), black drum (*Pogonias cromis*) and a variety of other fish species were observed floating on the surface. Perforated air bladders were found in five sheepshead collected in bottom trawls after the detonations (Andre Landry, unpublished data). Fifty-four sheepshead and 69 black drum were stranded along 13.7 mi (22 km) of beach immediately inshore of the removal site over the next 14 days (figures 5 and 6).

Turtles. Beaches in Statistical Area 18 were surveyed for approximately 312 and 320 man-hours in 1986 and 1987, respectively. In 1985, however, NMFS personnel examined the beaches in this area only in response to public reports of stranded marine life. From March 19 to April 19, nine turtle strandings *were* reported in Statistical *Area* 18 during 1985,51 in 1986, and only 4 during the same period in 1987. Based on the state of decomposition of a turtle and the reported date of stranding, one turtle from each of the 1985 and 1986 data *sets* had died previous to the March-April sampling period. At least 22 explosions were reported in Texas State waters of Area 18 during this period in 1986, and one explosion was reported in Federal waters *in* 1987. Comparison of turtle strandings during periods characterized by high and low numbers of offsbore explosions (March-April 1986 and March-April 1987, respectively) suggested a positive relationship between the frequency of explosions *and* tbe stranding of turtles (figure 7). Strandings of turtles in western Louisiana (Statistical Area 17) were minimal for 1985 (3 turtles) and 1987 (30 turtles). However, in 1986, 122 stranded turtles were reported; 119 of the strandings occurred during May through September.

Two turtles that were stranded on beaches within two weeks after explosions at monitored platforms were autopsied. One loggerhead showed no characteristics consistent with explosive impacts. External inspection of another loggerhead found dead two days following a nearshore explosion revealed a bloated carcass with green flesh and gas bubbles beneath the scutes. Necropsy showed lung hemorrhage, four ruptures of the right atrium, and bloody fluid in the pericardial sac (Andre Landry, personal communication). Lung hemorrhage is consistent with impacts resulting from underwater explosions. However, this condition, along with ruptures in the beart, may also be the result of postmortem decomposition.

Marine mammals. Between March 19 and April 19, six dolphins (all *Tursiops truncatus*) stranded in 1985, 41 (40 *T. truncatus* and 1

Stenella sp.) in 1986, and 22 (*T. truncatus*) in 1987 in Statistical Area 18. Of these, 15 dolphins in 1986 and 22 in 1987 were considered either fetuses or newborns (length ≤ 47.2 inches [120 cm]). Based on state of decomposition and the reported date of stranding, one adult and two fetal dolphins in 1986 and one adult dolphin in 1987 had died before the March 19 to April 19 sampling period. Only three stranded dolphins were reported in Statistical Area 17 between January 1985 and December 1987. Although dolphins may be impacted by explosions, the relationship between the stranding of dolphins and offshore explosions was not readily apparent (figure 8).

Biological Monitoring at Removal Sites

Turtles. A total of 6 turtles was observed at 3 of 11 removal sites monitored by NMFS (table 1). One sighting of a green turtle (*Chelonia mydas*) and multiple sightings (4 and 7 observations) of two loggerhead turtles were made over a 4-day period near a platform 83.9 mi (135 km) off Sabine Pass just prior to its removal on July 20-21, 1986. After the first of six explosions an upside-down, stunned turtle, presumably a loggerhead, was observed drifting downcurrent about 19.7 ft (6 m) below the surface. Three sightings of loggerhead turtles were reported at two other removal sites. All were observed more than 3,002 ft (915 m) from the detonation sites during helicopter surveys. One was seen during a preblast survey and two during postblast surveys. All turtles were on the surface and dove underwater when approached by observers in a helicopter.

Marine Mammals. Between O and 26 dolphins were observed at each of 10 removal sites monitored by NMFS (table 1). On three occasions their presence delayed the scheduled detonation of explosives. Scaring dolphins with small explosive charges and herding dolphins with boats were not always effective in moving the dolphins away from the detonation site. The minimal effort expended on feeding dolphins to lure them from the removal site was unsuccessful.

Fishes. Fishes were killed at all platform removal operations (table 3). The explosive removal of structures in water depths > 65.6 ft (20 m) killed more fish than at shallower sites. An estimated 1,000-2,500 red snapper (*Lutjanus campechanus*) and several cobia (*Rachycentron canadum*), two species under Federal management, were killed at one removal site, where water depth was 137.8 ft (42 m). Postblast samples of fish mortalities showed greater species diversity at deeper sites. The number of fish killed decreased with subsequent explosions at structures requiring multiple detonations.

Exposure of Turtles to an Underwater Explosion

In June 1986, a platform off Bolivar Peninsula, Texas, was removed using 202.9 lb (92 kg) of explosives. Although in-water measurements of pressure levels were not recorded, values based on mathematical models were estimated to be 221, 217, 213, and 209 db for horizontal distances from the detonation site of 750; 1,200; 1800; and 3,000 ft (229 m, 366 m, 549 m, and 915 m), respectively (William Cummings, unpublished data). Two Kemp's ridleys (14.8 and 1.3 lb [6.7 and 0.6 kg]) and two loggerheads (9.3 and 12.1 lb [4,2 and 5.5 kg]) within 1,200 ft (366 m), as well as one loggerhead (15.0 lb [6.8 kg]) at 1,800 ft (915 m), were rendered unconscious by a simultaneous explosion of four 50.7-lb (23-kg) charges. Approximately 0.8 inch (2 cm) of the cloacal lining everted through the anal opening of the Kemp's ridley (14.8 lb [6.7 kg]) positioned at 750 ft (229 m). Ridleys (2.9 and 3.3 lb [1.3 and 1.5 kg]) at distances of 1,800 and 3,000 ft (549 and 915 m) were apparently unharmed. Unconscious turtles recovered when removed from the cages. All loggerheads displayed abnormal pink coloration caused by dilated blood vessels at the base of the throat and flippers. This condition continued for approximately three weeks, after which time all turtles appeared normal. These data verified that explosions can result in both near and far-field injuries to turtles (table 4).

Supplementary data pertaining to fish were collected in conjunction with these experiments. Sheepshead, Atlantic croaker (*Micropogonias undulatus*), Atlantic bumper (*Chloroscombrus chrysurus*), Atlantic spadefish (*Chaetodipterus faber*) and black drum were found dead floating on the surface at the blast site. Necropsy of dead floating fish revealed internal damage ranging from minor tears in the gas bladder to severe lesions of abdominal organs (George Guillen, personal communication). The same species were subsequently found dead on adjacent beaches. Twenty-nine of ninety-nine drift bottles released at the platform were found in the same beach locality as the fishes within two days after the explosion, indicating that surface currents probably were strongly directed toward shore. Three of ninety-nine seabed drifters released at the platform were also recovered along the beach.

Review and Discussion

Relation of Strandings to Explosions

Dates and locations pertaining to the use of underwater explosives at offshore oil and gas structures are scattered throughout oil and gasindustryfiles. Nogovernment agency or agencies maintain a complete database for explosives operations in offshore waters and coastal embayments. It would be a very long, arduous, and costly task to locate these records and compile them into an accurate and useful data base even with tbe cooperation of everyone involved. But compilation of these data is a prerequisite to comparing sea turtle strandings with the frequency and location of offshore explosions.

Nevertheless, there is a striking relationship between the number of strandings that occurred during a period of high versus low removal activity; 51 turtle strandings occurred in Statistical Area 18 during March 19-April 19, 1986, following 22 nearshore explosions versus 4 strandings during the same period in 1987, when no explosions were reported. Thus, it appears that platform removals may have affected the strandings of turtles near Bolivar Peninsula. Although there is not such a striking relationship between the strandings of dolphins and explosive platform removals, more dolphins were found stranded in Statistical Area 18 during the March 19-April 19 time period in 1986 than in 1985 or 1987.

It is difficult to establish a connection between the stranding of an individual sea turtle and a particular offshore explosion. Turtles found on beaches are usually in such poor condition that it is impossible to determine cause of death even with a necropsy. Dead sea turtles generally sink until decomposition gases float the carcass to the surface two to three days later. Consequently, movement of a carcass may not correspond with that of drift cards released after an underwater explosion. Similarly, it is difficult, using surface observations, to document dead turtles immediately after an underwater explosion. A fresh sea turtle carcass placed 2.2 mi (3.6 km) off the coast of the southeastern United States took 13 days to wash ashore (Sally Murphy, personal communication). Depending on the magnitude and direction of winds and currents, dead turtles *may* take weeks to wash ashore. The greater the distance from shore at time of death, the less likely the carcass will reach the beach. In addition, injured turtles are less able to avoid predators or may swim for undetermined distances and times before succumbing to injuries. Murphy also observed sharks feeding on turtle carcasses at sea. Thus, *an* absence of stranded turtles on the beach is not conclusive evidence that turtles were not injured by offshore explosions.

Relation of Shrimping Effort to Strandings

An increase in turtle strandings did not correspond with an increase in shrimp fishing effort. In Statistical Area 18, strandings were high during March-April 1986. However, shrimping effort within 59.1 ft (18-m) depths was low during March and April in 1985, 1986, and 1987 (130-340 vessel days fished, 50-390 days, and 100-240 days, respectively), while fishing effort was much higher in summer and fall months (840- 1,430 vessel days fished, 570-700 days, and 2,400 days through July, respectively).

Turtle strandings increased along the Atlantic coast when the shrimp season opened and fishing effort was high (Sally Murphy). However, low shrimping effort can result in a high incidence of turtle capture and subsequent death in areas where sea turtle density is high. Ogrensuggests that the high number of reported captures of juvenile Kemp's ridleys by shrimpers in the mid-1970's may be correlated with high densities of portunid crabs, a primary food source of the ridley turtle.

Effects of Explosions

Information about the effects of underwater explosions on sea turtles is extremely limited. O'Keeffe and Young (1984) describe a series of three underwater shock tests conducted by the Naval Coastal Systems Center near Panama City, Florida in 1981. Despite helicopter surveys for turtles prior to each of three detonations of 1,200 lb (544 kg) of trinitrotoluene (TNT) at middepth in water about 121.4 ft (37 m) deep, at least three turtles were found after the explosions. One turtle was killed at a distance of 500-700 ft (152-213 m); one turtle at 1,200 ft (366 m) sustained minor injuries; and one turtle at 2,000 ft(610m) appeared to be uninjured. O'Keeffe and Young (1984) assumed that shock waves injured the lungs and other organs that contained gas, as is known to occur in birds and mammals. Researchers also expected the eardrums of turtles to be sensitive and smaller turtles to suffer greater injuries from the shock wave than larger turtles.

In the absence of other information, O'-Keeffe and Young (1984) estimated a safe range of at least 259.2 ft/2.2lb$^{(1/3)}$ (79m/kg$^{(1/3)}$) of explosive. This method predicts a safe range beyond 1,161.5 ft (354 m) for the detonation of a 203-lb (92-kg) explosive. Ourdata show adamagedcloacal lining in a loggerhead turtle at a distance of 1,200 ft (366 m) from the simultaneous detonation of four charges totaling 203 lb (92 kg). In addition, one loggerhead was rendered unconscious at a distance of 3,000 ft (915 m). Experimental animals were revived during the handling required to assess their physical condition. However, in the wild, unconsciousness will render a turtle more susceptible to predation, and the unconscious turtle may sink to the bottom. Although resting turtles can remain submerged for several hours, the effects of submergence on stunned turtles is unknown.

Little information is available on the effects of explosions on marine mammals (0'Keeffe and Young, 1984). Research conducted at the Lovelace Biomedical and Environmental

Research Institute on the impacts of underwater explosions on dogs, sheep, and monkeys showed similarities between species for response to shockwaves as a function of specimen size. Two types of injuries resulted from underwater explosions: (1) hemorrhaging in and around the lungs, and (2) excitation of radial oscillations of small gas bubbles normally present in the intestine (Richmond, Yelverton, and Fletcher, 1973; Yelverton et al., 1973).

Goertner (1982) developed a computer model to predict distances at which marine mammals exposed to underwater explosions would sustain injuries. The model estimated that an Atlantic bottlenose dolphin calf would suffer slight injury at approximately 3,901 ft (1,189 m) from a 1,200-lb (544-kg) charge of TNT detonated at 124.7 ft (38 m) in deep water. O'Keeffe and Young (1984) suggested doubling this estimate to provide an adequate margin of safety. Though currently unavailable, models should be developed specifically for sea turtles and should address conditions encountered in platform removal operations. The magnitude of the impact zone will vary from site to site due to the weight and position (inside or outside piling; above or below mudline) of explosives, water depth, reflectivity of the bottom substrate, and reflectivity of density gradients within the water column. Therefore, existing models require refinement before they can be used with a high degree of confidence to predict safe ranges for turtles.

Since fish aggregate around offshore platforms (Shinn, 1974; Hastings, Ogren, and Mabry, 1976, Jackson, Baxter, and Caillouet, 1978; Gallaway and Martin, 1980; Gallaway and Lewbel, 1982; Tennison, 1985), probably for protection and food, similar factors may operate for sea turtles. Are sea turtles regularly associated with offshore energy structures, or is it only a chance event that turtles may be in the vicinity of a structure when underwater explosives are used?

Data collected at all structure removal sites monitored by NMFS observers from April 1986 through September 1987 show a total of 6 turtle sightings at 3 of 11 structures. Three of these turtles were seen at a single platform in July 1986 by Tim Fontaine (personal communication), who observed them at night apparently feeding on juvenile blue crab (*Callinectes sapidus*) and rock shrimp (*Sicyonia brevirostris*).

A number of turtles have been observed in the vicinity of oil and gas structures in Gulf of Mexico waters off the Texas and Louisiana coasts. Lohoefener (personal communication) reports sighting over 200 turtles during aerial surveys, many in areas characterized by high concentrations of oil platforms. Fuller and Tappan (1986) reported two turtles observed by divers at Louisiana oil platforms. One of these, a leatherback (*Dermochelys coriacea*), apparently became entangled under the platform and died. We assume these structures provide a resting place or a location where food is readily available. Diving clubs have reported 27 underwater observations of sea turtles in the northwestern Gulf of Mexico through August 1987. Nine of these were associated with Texas oil platforms (Sharon Manzella, personal communication).

Eight scientific studies conducted in the Gulf of Mexico between 1975 and 1985 offer insights on the distribution and behavior of turtles around natural and artificial reef structures, although the studies did not focus on sea turtles (Rosman et al., 1987). The conclusion, based entirely on observations by divers, submersibles, and time-lapse photography, is that underwater sightings of turtles were infrequent. Photographs often showed turtles lying on the sea floor within the confines of the camera assembly. More turtles were photographed at night than during the day. Successive photos suggested that turtles might remain within 9.8 ft (3 m) of the camera assembly for more than 2-3 h. One individual loggerhead, identifiable by barnacle patterns on the shell, was seen at the West Flower Garden Bank in the Gulf of Mexico by scuba divers in February, June, and September of 1980. Rosman et al. (1987) suggested the superiority of time-lapse photography over diver observations based on 231 turtle sightings in 25,186 photographs versus 1 sighting in 77 dives in the southwest Florida study.

At the Buccaneer Platforms off Galveston, Texas, 4 sightings were reported during 527 research dives between August 1977 and September 1980 (Rosman et al., 1987). Two of the four turtles were lying on the sea bottom in physical contact with the structure. The number of sightings may represent a minimum number of turtles in the area because the attention of divers was not focused on turtles. In a similar situation on August 20, 1987, Gitschlag conducted a task-oriented dive at Buccaneer without sighting a turtle, although Renaud observed one turtle twice within 20 minutes from a dive boat at the surface.

Further evidence that turtles are found around other manmade structures comes from studies at Florida Power & Light Company's St. Lucie Plant. Between 1976 and 1986, 1,530 sea turtles were entrained through three cooling water inlet pipes (12-16-ft [3.7-4.9-m] diameter) located 1,200 ft (365 m) offshore. The species composition of turtles included 86 percent loggerheads, 13 percent greens, and about 1 percent leatherbacks, Kemp's ridley, and hawksbill (*Eretmochelys imbricata*) combined (Florida Power and Light Company, 1986).

The above data show that turtles are found in the vicinity of offshore structures. However, the nature of this association cannot be satisfactorily described without further investigation. Quantification of resident versus transient turtles, distance at which resident turtles may range from structures, and seasonal abundance in various geographic areas are just a few of the questions that remain to be answered.

It is interesting to note a difference in regulations for installation versus removal of offshore oil and gas structures. Extensive environmental impact statements are prerequisite to installation of offshore structures. In contrast, prior to 1986 of ormal environmental monitoring was required for structure removal, despite the fact that these structures represent more hard substrate habitat than occurs in all the natural reef and hard bank areas off the Louisiana coast (Reggio, Van Sickle, and Wilson, 1986). If recent estimates are correct, between 1,600 and 2,000 offshore oil and gas structures are to be removed from the Gulf of Mexico bytheend of thecentury. Thisraises serious questions about the impacts not only of explosives but also of the potential loss of valuable habitat to awidevariety of marine life.

While it is important to continue monitoring the biological impacts of explosive offshore removals, it is also necessary to develop methods to disperse protected marine life from removal sites prior to detonating explosives. Standard procedures could then be implemented to minimize impacts to turtles and dolphins while simultaneously reducing the delays affecting the structure removal process at present.

Conclusions

Although sea turtles and dolphins are found at offshore energy structures, the details of this association have not been thoroughly investigated. No cause-and-effect relationship between turtle and dolphin mortalities and offshore explosions has been documented because no dead animals have been recovered at removal sites, Fish were killed at all removal sites monitored by NMFS personnel. Experimentally exposed turtles and, consequently, wild turtles can be injured by underwater explosions. Comparison of turtle stranding data during periods characterized by high and low numbers of offshore explosions suggests a connection between explosions and the number of turtle strandings; data are less supportive of a relationship between explosions and dolphin strandings. The high number of dead turtles stranded in close proximity to nearshore structure removals provides circumstantial evidence that at least some may have been killed by underwater explosions. However, it is apparent that other factors, including capture in shrimp trawls, ingestion of plastic refuse, and entanglement in debris, are also responsible for turtle mortalities.

Acknowledgments

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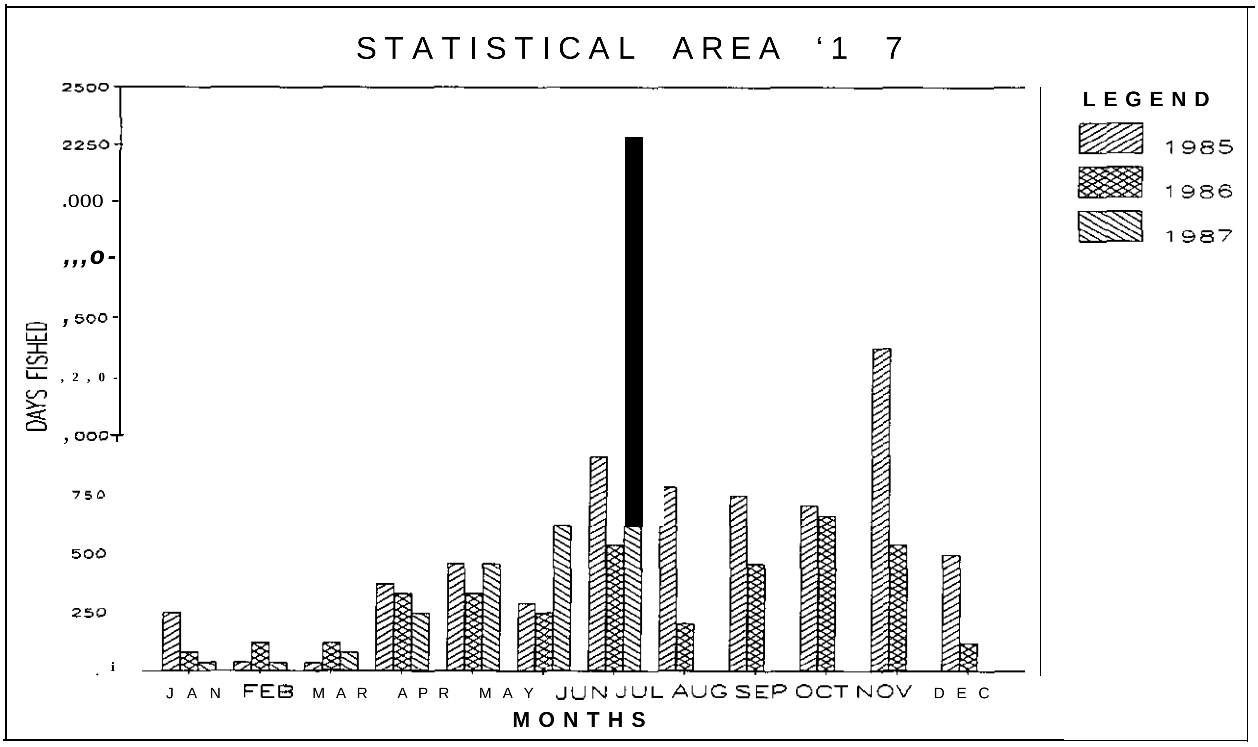

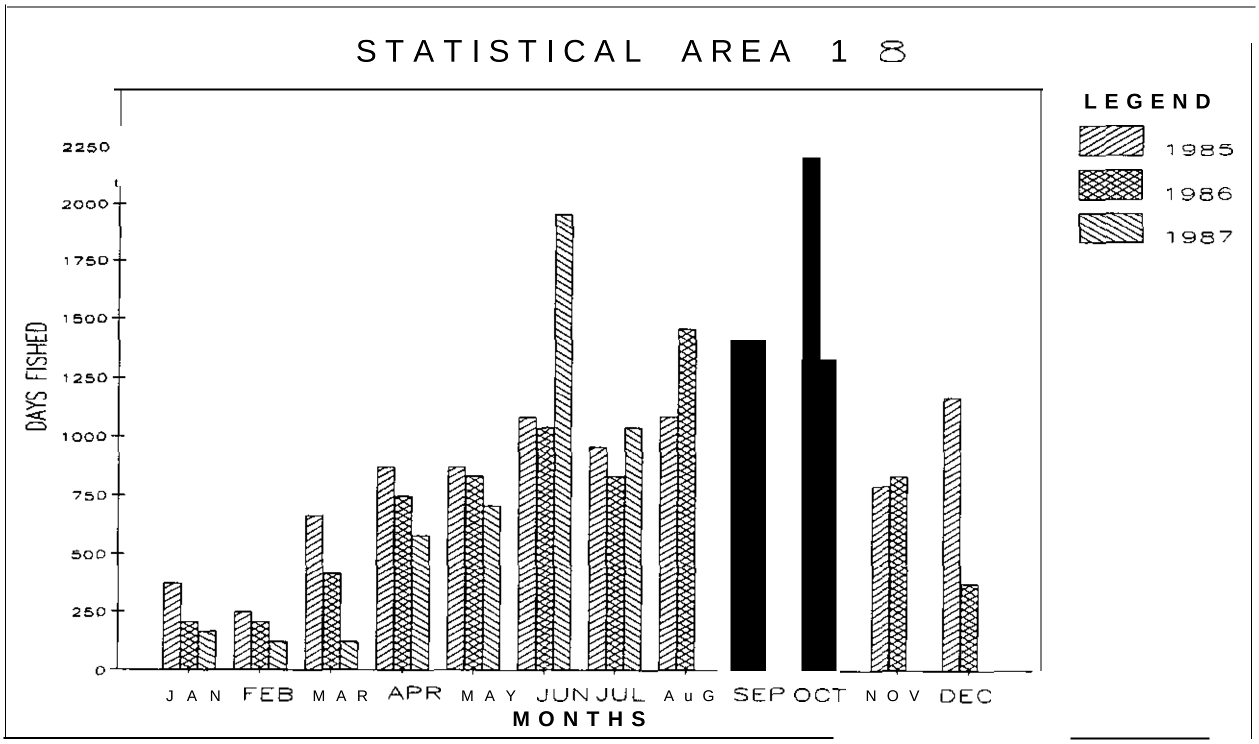

Figure 1. Offshore shrimping effort in 0-59.1 ft (0-18 m) depths for Statistical Areas 17 and 18,1985-1987

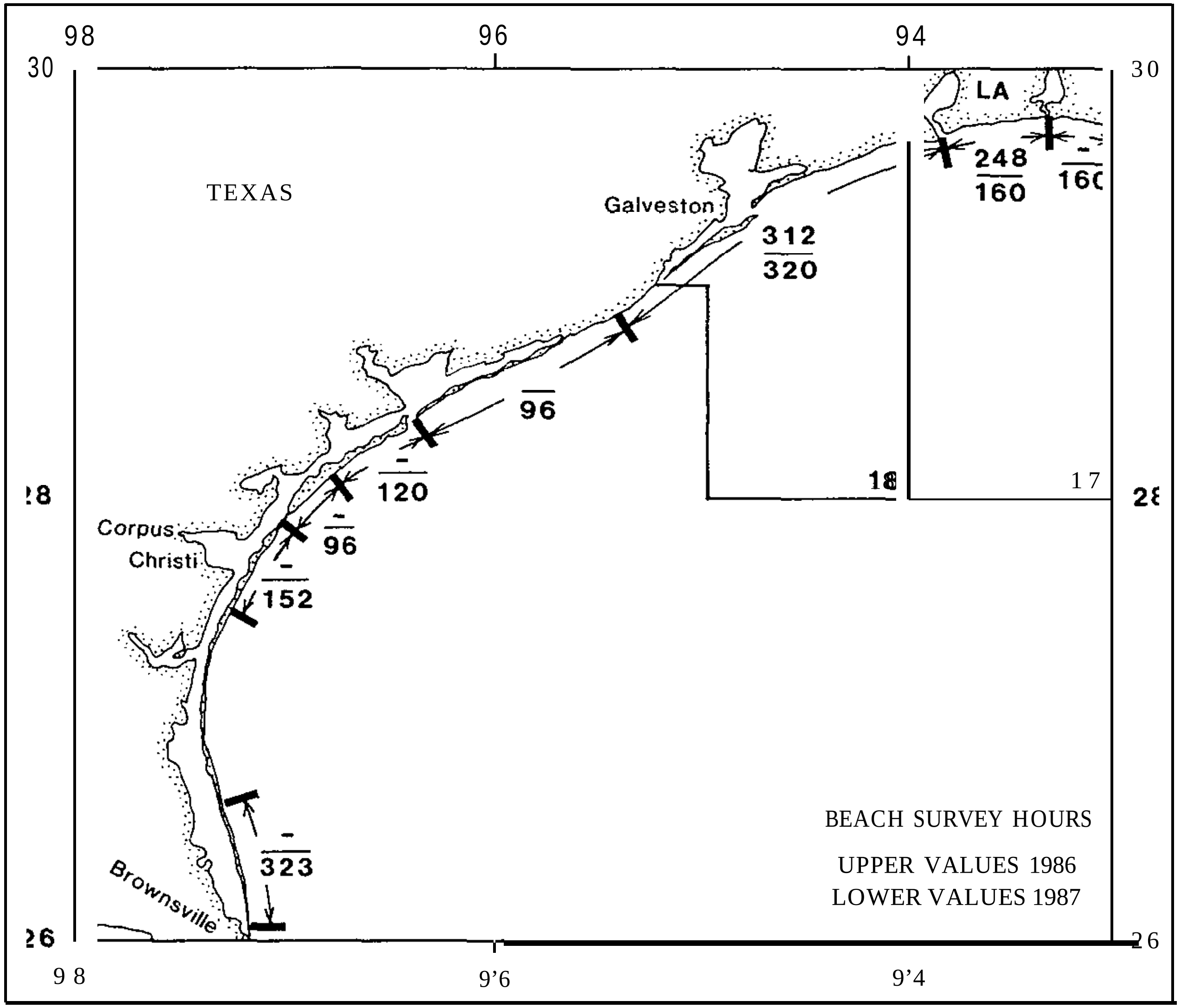

Figure 2. NMFS-sponsored beach survey effort (man-hours) for monitoring turtle stranding events along the western coast of the Gulf of Mexico. Upper numerals represent 1986 hours and lower numerals 1987 hours expended on surveys of the coastline as indicated.

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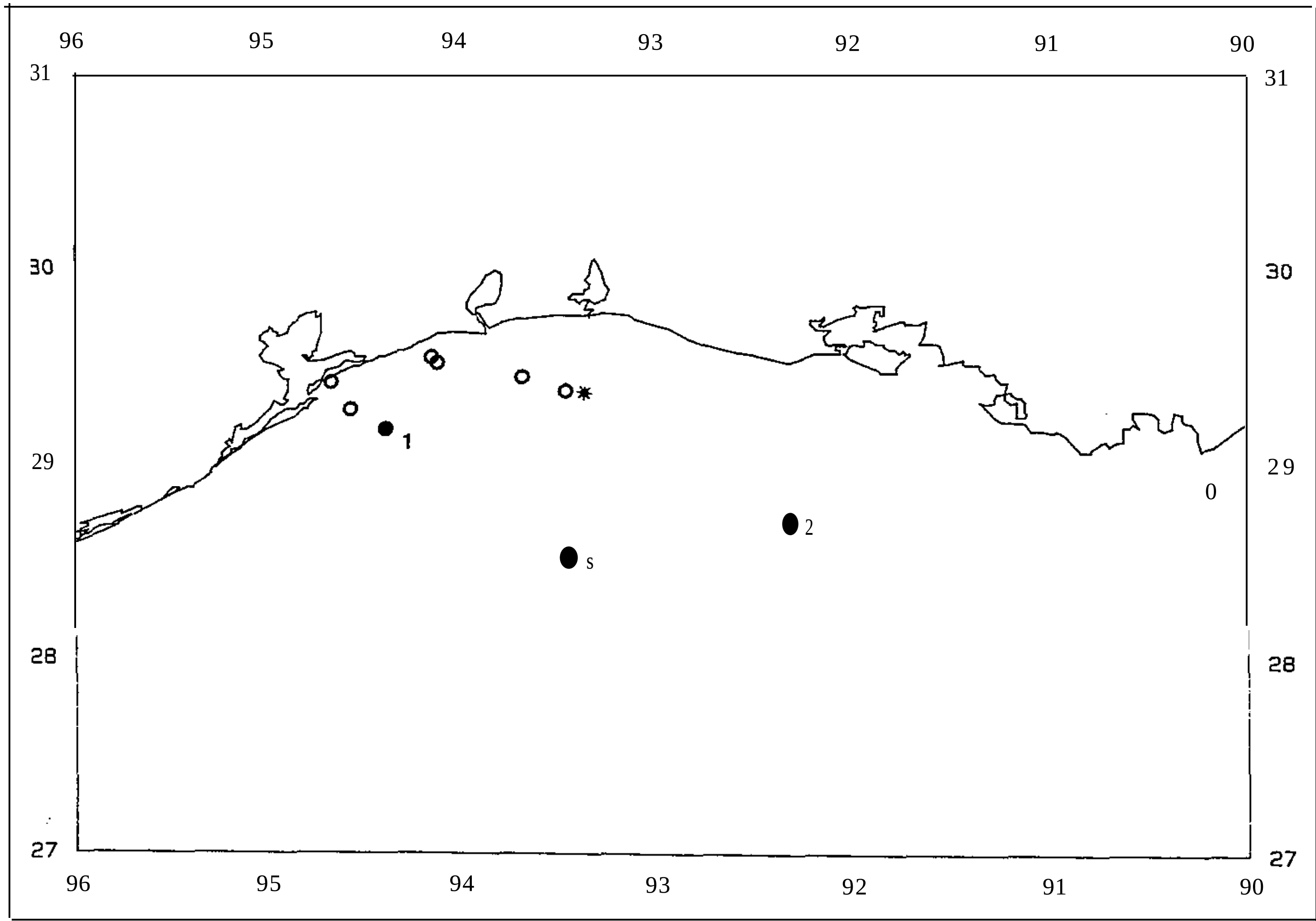

Figure 3. Locations of NMFS-monitored platform and caisson Removals. Open circles indicate removal locations where sea turtles were not observed. Solid circles with adjacent numerals indicate locations and frequencies of turtles sightings. An open circle marked titian asterisk indicates two caissons were removed.

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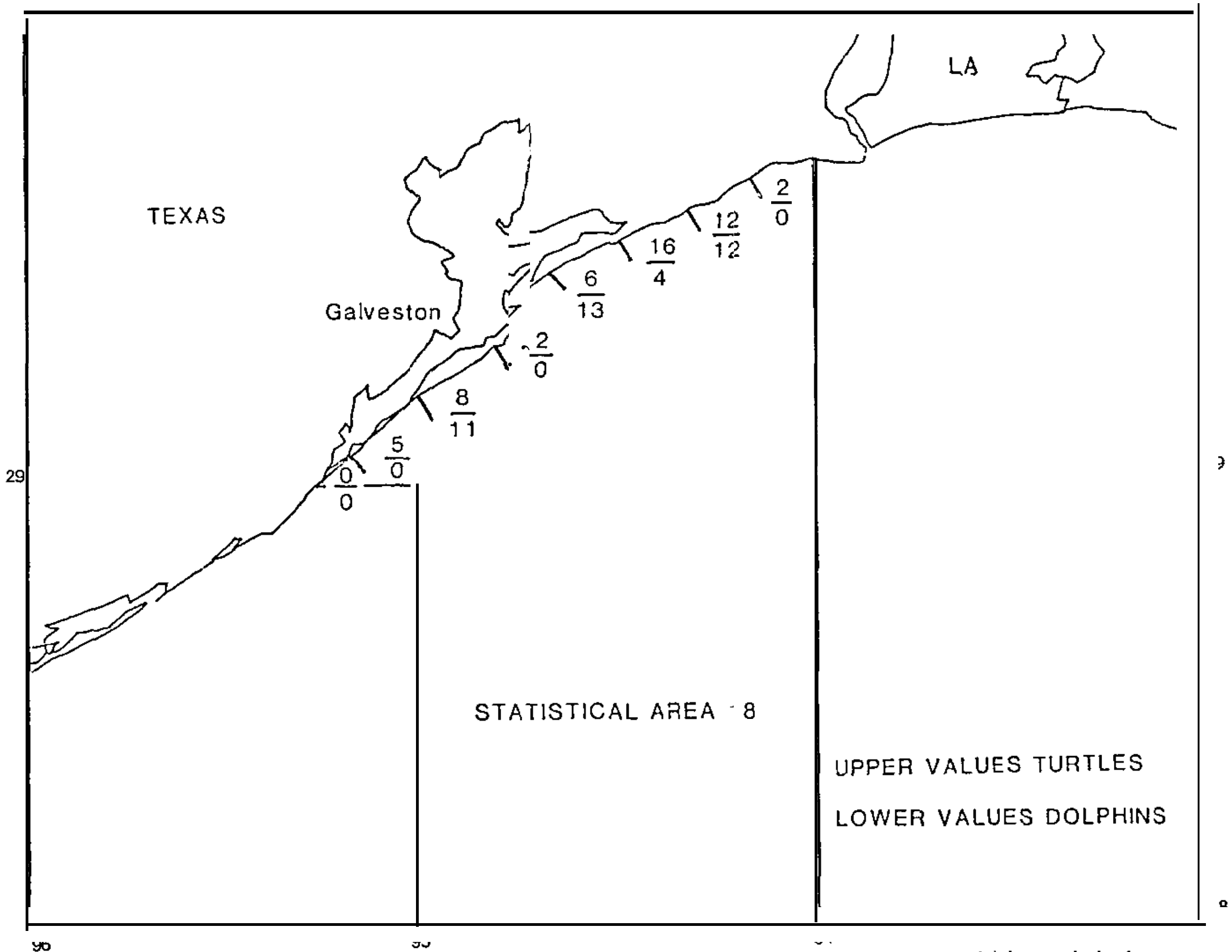

Figure 4. Reported strandings of sea turtles (upper numerals) and dolphins (lower numerals) in Statistical Area 18 between March 19 and April 19, 1986.

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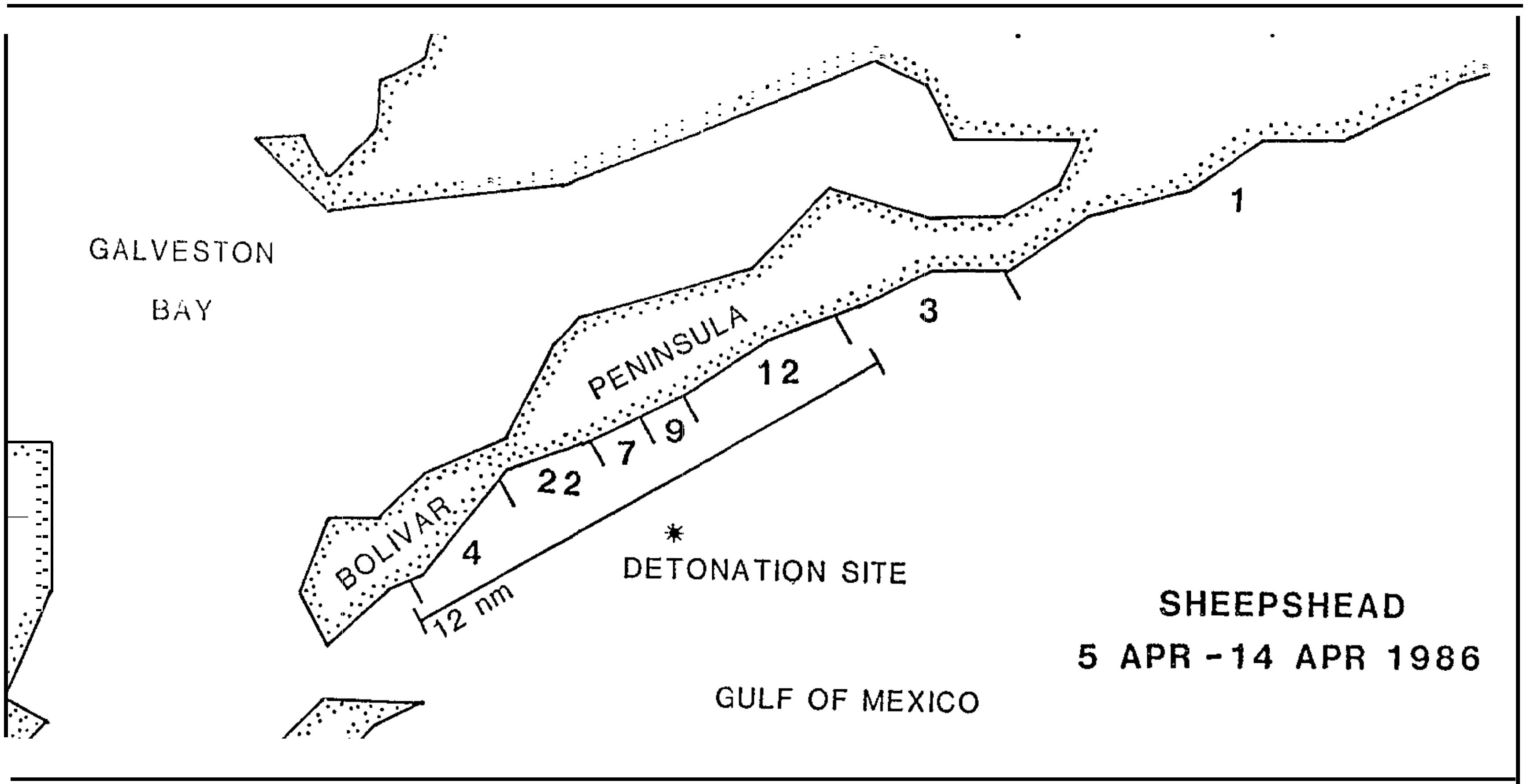

Figure 5. Strandings of sheepshead reported on Bolivar Peninsula from April 5-19,1986.

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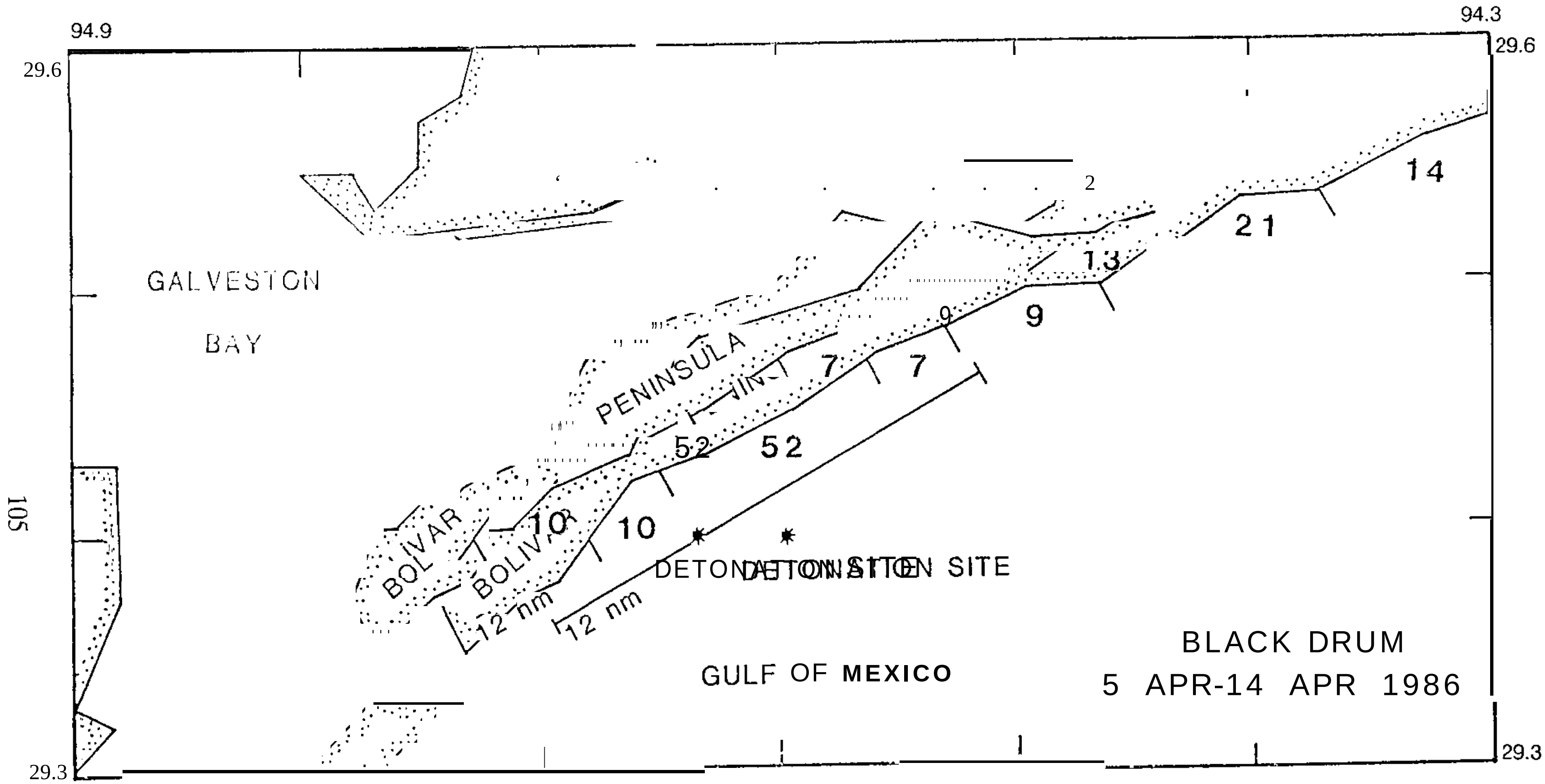

Figure 6. Strandings of black drum reported on Bolivar Peninsula from April 5-19,1986

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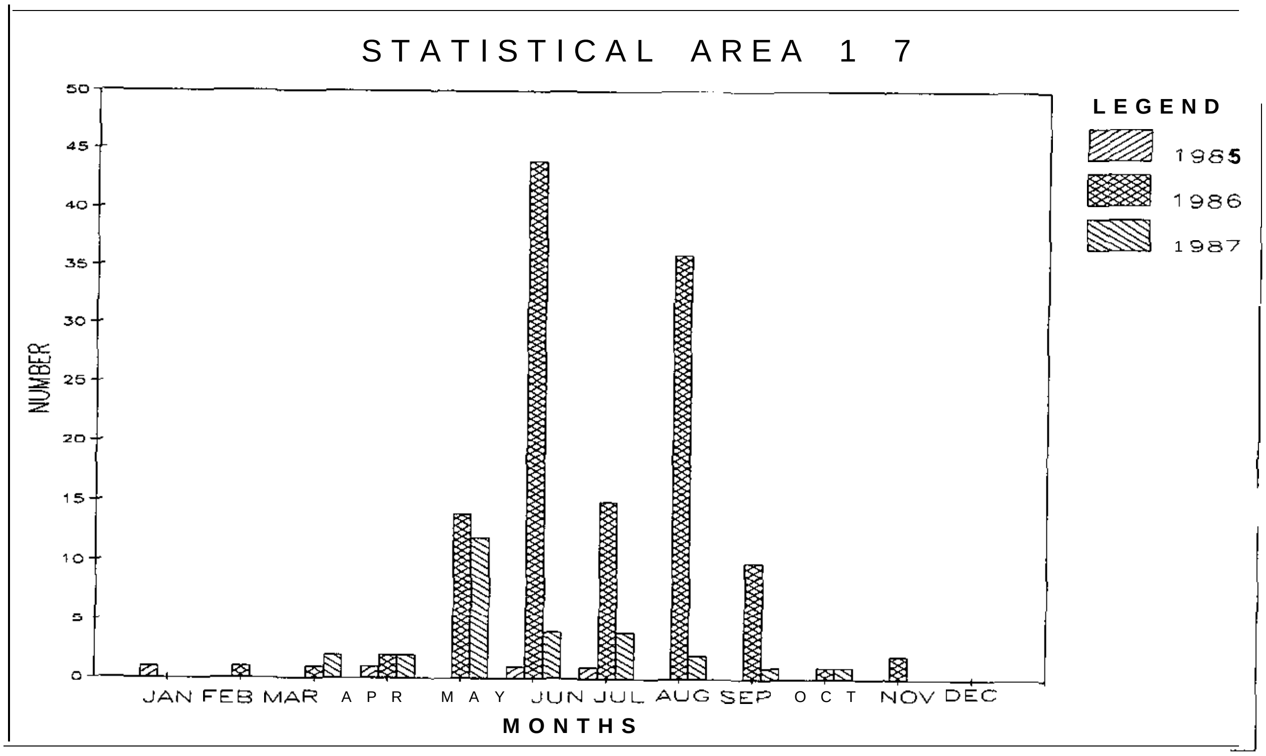

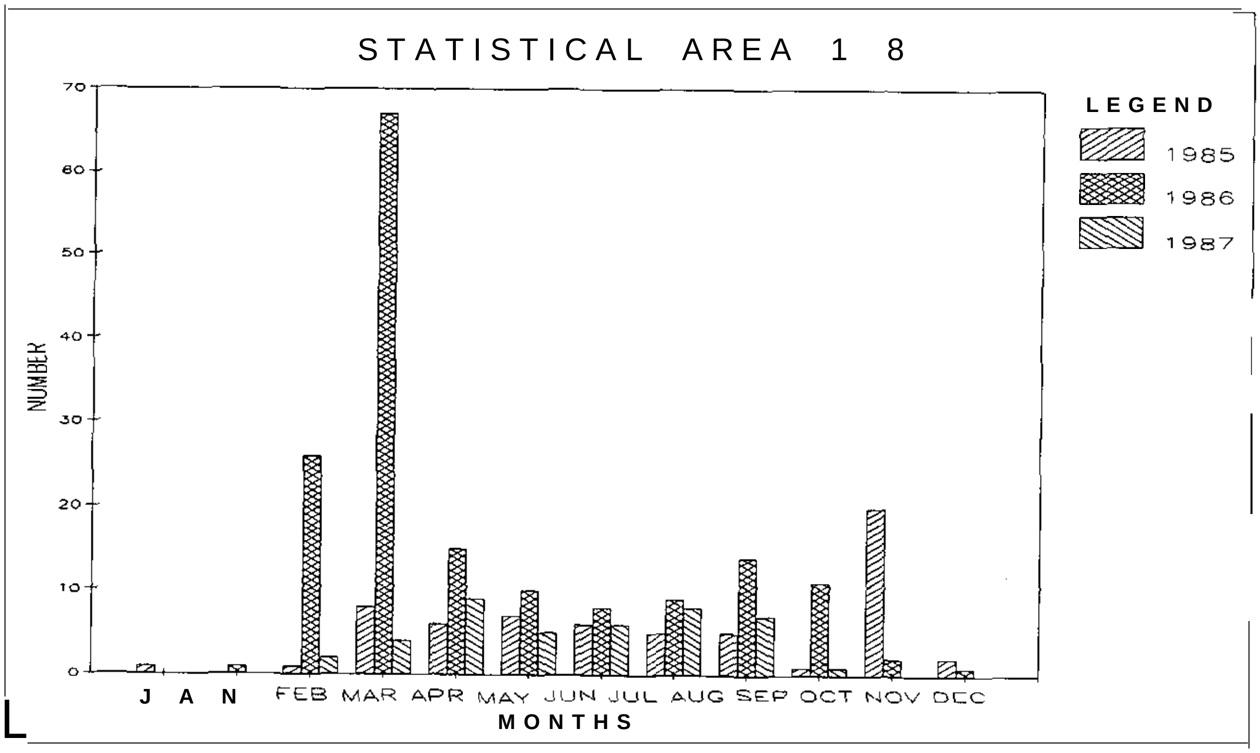

Figure 7. Frequency of sea turtles strandings reported in Statistical Areas 17 and 18, 1985-1987. Strandings in 1985 were reported by the public and confirmed by NMFS.

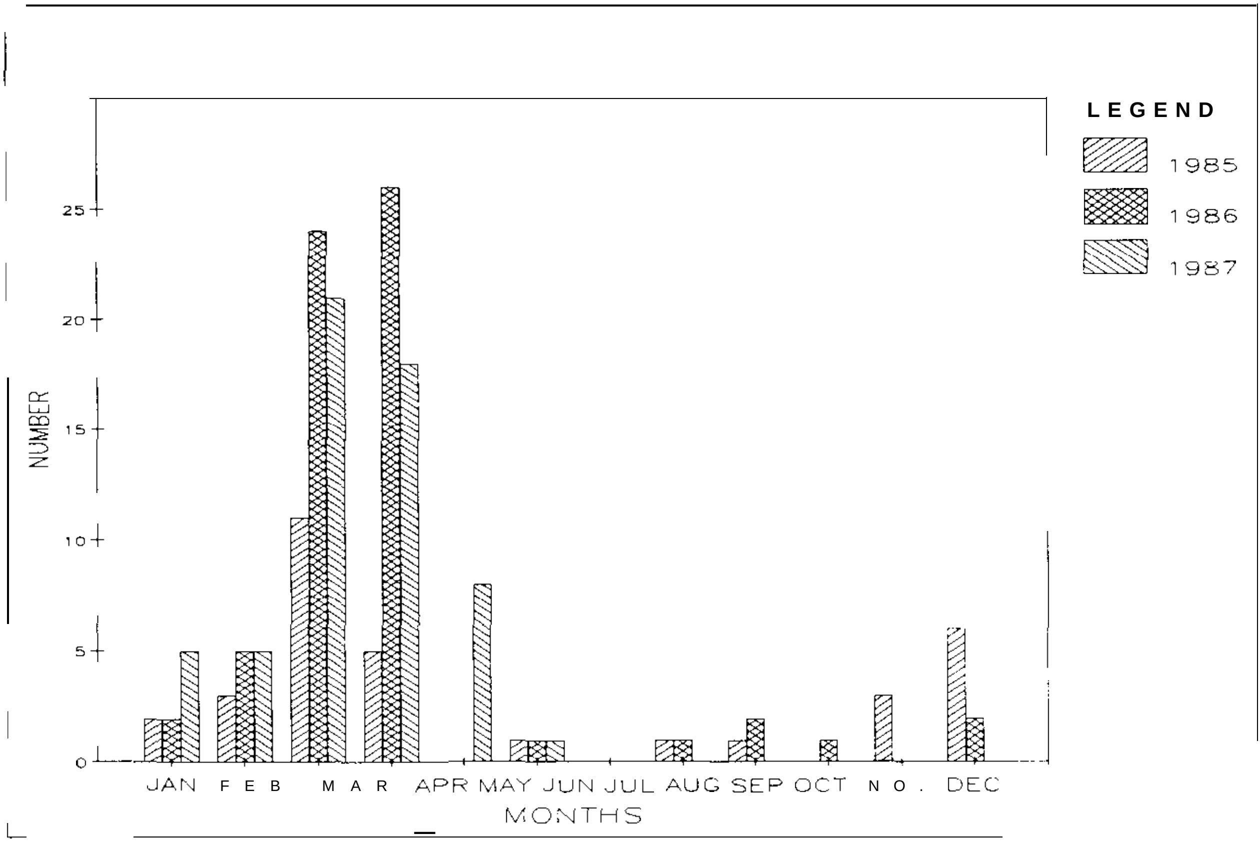

Figure. 8. Frequency of marine mammal strandings reported in Statistical Area 1S, 1985-1987. Strandings in 1985 were reported by the public and confirmed by NMFS.

Table 1

Man-hours of Observation at NMFS-monitored Removals
with Accompanying Sightings of Turtles and Dolphins
(Refer to figure 6 for platform locations.)

Date of Removal	Approximate Distance from Shore (nmi)	Depth (m)	Structure Removed	Man-hours of Observation	Turtles Sighted	Dolphins Sighted
				day/night		
4/86	1	9	Platform	8/0	o	26
7/86	75	42	Platform	76/48	3	18
11/86	10	15	Platform	28/14	0	0
12/86	6-9	12	2 Caissons	21/0	o	15
3/87	55	39	Platform	52145	2	24
4/87	21	16	Caisson	13/0	1	13
6187	17	27	Platform	73/0	o	26
9187	15-18	10-15	3 Caissons	30/12	o	17

Table 2

March-April 19S6 Schedule of Removals
of Oil and Gas Field Structures off Bolivar Peninsula

(The total weight (kg) of explosive utilized at each detonation and the number of turtles and dolphins stranded in Statistical Area 18 during this time period are also presented.)

Date	Weight of Explosive (kg)	Approximate Time (H)	Lat.	Long.	Turtles	Dolphins
1-18 March					9	4
19	45	1632	29°25′	94°39 ‘	o	3
	109	1758	29°25′	94°39′		
20	27	2235	29”25 ‘	94”39’	1	0
21	109	1703	29”25 ‘	94”39’	3	0
22	27	1130	29”25’	94°39’	0	0
23	27	0815	29°25 ‘	94”39’	0	1
24	109	1425	29°25 ‘	94”39	o	0
25	45	1100	29°25′	94°39′	0	()
	76	1333	29°25 ‘	94°39 ‘		
26	18	1630	29°25 ‘	94°39′	5	2
27	109	1220	29”25’	94”39 ‘	1	0
	27	1440	29°25′	94°39 ‘		
28	27	1545	29°25 ‘	94”39 ‘	3	0
29	27	0845	29°25′	94°39′	0	0
	109	1310	29”25’	94°39 ‘		
	55	2330	29”25 ′	94°39′		
30	35	1020	29”25 ′	94”39’	3	14
31	109	1015	29”25 ′	94”39 ‘	1	0
1 April	23	1710	29°25’	94°39′	2	4
2	76	0805	29°25′	94”39’	0	()
3					0	0
4					1	4
5	59	1251	29°25′	94°39′	2	1
	109	1451	29°25 ′	94°39′		
6-19					29	12
20-30					32	5

Table 3

Fish Collected at NMFS-monitored Structure Removals
(surface collection/bottom collection)

Structures Depth (m):	12/86 2 Caissons 12	3/87 Platform 39	4/87 Caisson 16	6/87 Platform 27	9/87 3 Caissons 10-15
Fish Species by Family					
Ariidae					
Hardhead cattish					18/0
Balistidae					
Gray triggerfish	o	1/0		1/0	2/0
Blenniidae					
Blenny	0/1				
Carangidae					
Atlantic bumper					27/0
Blue runner				32/10	0/1
Unknown		1/0			
Clupeidae					
Menhaden	5/0		8/14		
Elopidae					
Ladyfish					4/0
Engraulidae					
Anchovy	0/1				
Ephippidae					
Atlantic spadefish	5/1	6/0		31/1	63/18
Grammistidae					
Soapfish		2/0			
Kyphosidae					
Bermuda chub		5/0		1/0	
Lutjanidae					
Lane snapper		17/0		710	1/5
Mutton snapper				3/1	
Red snapper		6/0	12/1	I/o	20/2
Vermilion snapper		5/0			
Pomadasyidae					
Grunt		1/0	2/1		

Table *3*

Fish Collected at NMFS-mrmitored Structure Removals
(surface collection/bottom collection) (continued)

Structures Depth (m):	12/86 2 Caissons 12	3/87 Platform 39	4/87 Caisson 16	6/87 Platform 27	9/87 3 Caissons 10-15
Fish Species by Family					
Priacanthidae					
Bigeye		1/0			
Sciaenidae					
Black drum		6/0			
Croaker					72/1
Seatrout	1/0	3/0	4/2		2/3
Spot			16/7		
Unknown	1/0				
Serranidae					
Unknown				4/0	
Sparidae					
Knobbed porgy		4/0			
Pinfish	2/0				2/0
Sheepshead	8/0	13/1	131/13	5213	5/3

Table 4

Description of **Turtle** Injuries with Respect to Distance from Explosion and Estimated **Energy** Level (db) of Shockwave

Tin-tie Species	Distance From Explosion (m)	Estimated **Energy** Level (db)	Immediate Injuries	1-H Post mast
Lepidochelys kempi	229	221	unconscious	2 cm of cloaca everted; vasodilation around throat and flippers; vasodilation lasted 2.3 weeks
Caretta caretta	229	221	unconscious	vasodilation around throat and flippers; redness around eye and nose; vasodilation lasted 2-3 weeks
L. kempi	366	217	unconscious	appeared normal
C. caretta	366	217	unconscious	normal behavior, but vasodilation present around base of flippers; vasodilation lasted 2-3 weeks
L. kempi	549	213	none visible	appeared normal
C. *caretta*	549	213	none visible	appeared normal except for vasodilation around throat and flippers; vasodilation lasted 2-3 weeks
L. kempi	914	209	none visible	appeared normal
C. caretta	915	209	unconscious	appeared normal except for vasodilation around throat and flippers; vasodilation lasted 2-3 weeks

The Relationship of Rigs-to-Reefs to U.S. Environmental Conservation Law

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Abstract

Legal and policy research examines the Rigs-to-Reefs concept as an alternative to obsolete petroleum production platform removal in the context of existing U.S. wildlife conservation law.

The Endangered Species Act and the Marine Mammal Protection Act and their implementing regulations provide procedures for the taking of endangered species and marine mammals. The Outer Continental Shelf Lands Act and its accompanying regulations require removal of obsolete platform structures. A recent review of those regulations requested comments on use of platforms as artificial reefs as an alternative to removal, but subsequent regulatory revisions did not include this option.

Concurrent with the regulatory proposals, it became obvious that the explosive removal of obsolete petroleum production structures could result in the death or injury of endangered sea turtles and protected marine mammals. This analysis reviews the compliance of the National Marine Fisheries Service and the Minerals Management Service (MMS) with the Section 7 consultation procedures mandated by the Endangered Species Act and the Section 101 Small Take Exemption requirements of the Marine Mammal Protection Act.

A review of the statutes, regulations, and legislative history was compiled as a basis from which to assess the regularity of permit procedures and the effectiveness of agency use of consultations. The objective of the review was to insure agency compliance with existing law. Initial review and analysis provided the impetus for improved agency permit review and subsequent modification of agency procedures for initiating consultations.

Introduction

The notion that obsolete oil production platforms can be good for fish and good for fishermen is now widely accepted. With the passage in 1984 of the National Fishing Enhancement Act (Public Law 98-623), the recognition that obsolete offshore structures could be valuable in developing artificial reefs for fishery enhancement and development became national policy. Included in that recognition was the potential of saving at least part of the high cost of removing an anticipated 20 to 30 obsolete rigs per year over the next 10 years (Reggio, 1987). But while Rigs-to-Reefs can make for good sport and good business, can the practice also make for good environmental policy?

As has been the case with so many technological developments from plastics to nuclear reactors, no one thought, when rigs were deployed off our shores, of the environmental consequences of removing them after they served their function and were no longer useful. One of the unforeseen environmental consequences of rig removals has been the potential hazard to protected marine species through the use of explosives in the removal of obsolete platforms.

The resultant controversy will be explored in the case study of several platform removals in the Gulf of Mexico set out below. In tracking the response of public interest groups, the offshore industries, and the government agencies responsible for protecting marine species, a policy question for the future emerges: how can we successfully blend the purposes and objectives of the National Fishing Enhancement Act with pre-existing mandates set out by national energy development *and* national conservation legislation?

The Legal Framework

The *Outer Continental Shelf (OCS) Lands Act*[1]

The Outer Continental Shelf Lands Act (OCS Act) (43 U.S.C. 1301 et seq.) declares the rights of the United States in exploring, developing, and conserving the natural resources off its coasts. Those natural resources are defined by the Act to include not only submerged oil, gas, and minerals, but also living resources such as fish, shellfish, and marine mammals (43 U.S.C. 1301(e)). The Secretary of the Interior has the authority to carry out the Act and to promulgate necessary regulations (43 U.S.C. 1334). Among the other duties it sets forth, the Act states that the Secretary "may . . prescribe and amend such rules and regulations as he determines to be necessary and proper in order to provide for the prevention of waste and conservation of the natural resources of the Outer Continental Shelf." This language has been construed by the courts to mean not only conservation of mineral resources, but all natural resources as defined by the Act *(Gulf Oil Corp. v. Morton,* 493 F. 2d at 144-45 (5th Cir. 1975)). In fact, some commentators have suggested that the Secretary's duty to exercise his authority to conserve all natural resources is mandatory, not discretionary, particularly when combined with the mandate of the National Environmental Policy Act (NEPA) (Gaines and Schmidt, 1978).

The regulations for leasing in the OCS, among other provisions, require that "[whenever practicable, the Director [of the Minerals Management Service] shall require the plugging and abandonment of any well which the Director determines is no longer useful" (30 C.F.R. 250.15). The process by which such an abandonment occurs was, until recently, set out in a series of orders from the regional OCS offices. The regulations also include a section on NEPA compliance (30 C.F.R. 250.34-4).

In a revision to the regulations proposed in 1986, the MMS solicited comments on amendments that would consolidate technical requirements and add provisions for platform removal by merging the various orders into a "single set of regulations which would apply generally to platforms and structures on theOCS'(51 *Fed. Reg. 8332,* March 18, 1986). The proposed language relating to removals required the lessee to remove all structures in a manner approved by the Regional Supervisor, clear the area of all obstructions, remove the platforms to a depth of at least 15 ft (4.6 m) below the mudline, and notify the agency by letter that the work had been completed. There were no provisions for advance notice of a removal, nor the assessment of potential environmental impacts from the use of explosives in the marine environment.

In the same proposed revision, the Service noted growing support for the concept of Rigs-to-Reefs and solicited comments on allowing platforms to remain in place entirely or partially "if there are benefits to be obtained and the multiple-use concept of the OCS will not be violated (51 *Fed. Reg. 9333-34).* The notice posed several questions about the alternative of allowing structures to remain in the OCS and sought views on opportunities, costs, technical problems, disrnption or enhancement of fisheries habitat, criteria for identifying platforms with artificial reef potential, maintenance, and liability (51 Fed. Reg. 9334).

The *Endangered Species Act*

The Endangered Species Act (ESA) (16 U.S.C. 1531 et seq.) was passed in the recognition that human activities were rendering species of fish, wildlife, and plants extinct or were threatening them with extinction. The Congress, in finding that these species were of value and should not be lost, stated its policy that "all federal departments and agencies shall seek to conserve endangered species and threatened species and shall utilize their authorities" to protect the ecosystems upon which such species depend (16 U.S.C. 1531(c)). The act restricts the taking of species presently in danger of extinction or likely to become so, regulates trade in them, provides for the designation and acquisition of critical habitat, and requires that Federal agencies consider impacts upon them in conducting various Federal activities (Bean, 1984). While the Departments of the Interior (U.S. Fish and Wildlife Service [USFWS]) and Commerce (National Marine Fisheries Service [NMFS]) are designated as the responsible agencies for carrying out the purpose of the Act, *all* Federal agencies are charged with ensuring that "any action authorized, funded, or carried out by such agency. . is not likely to jeopardize the continued existence of any endangered species or threatened species" (16 U.S.C. 1536). The method whereby each agency is to ensure that no jeopardy exists is called the "Section 7 Consultation, " after the portion of the Act cited, which requires that every agency consult with either Interior or Commerce before undertaking an action.

Regulations interpreting and implementing Section 7 of the Act are set out at 50 C.F.R. 402.04 et seq. The onus is on the acting agency to identify activities that may affect listed species or their habitats and then to initiate consultation with either USFWS or NMFS. In the case where an agency has not identified such a "may affect" situation, consultation may be requested by either service. After a threshold examination has been conducted to determine if a "may effect" situation exists, the appropriate Service issues a biological opinion to the requesting agency. If the consultation and biological opinion conclude rhat the agency action will harm endangered species or offers reasonable and prudent alternatives that would prevent potential harm, rhe agency may issue an "incidental take statement," which specifies the impact of the take (number of individuals), delineates the reasonable and prudent measures to be taken, and sets forth terms and conditions under which the activity must be conducted (16 U.S.C. 1536(b)(4)).

The *Marine Mammal Protection Act*

The third statute applicable to rig removals is the Marine Mammal Protection Act (MMPA) (16 U.S.C. 1361 et seq.). The Act generally places a moratorium on the taking of any marine mammals, but provides several specific exceptions to the prohibition. The exception relevant to tbe instant situation is found at Section 101(a)(5) of the Act, which allows for the incidental take of small numbers of marine mammals during an activity other than commercial fishing if tbe proposed take will have a negligible impact on the affected species or stock. The Secretary may issue a permit after he makes a finding of "negligible impact" following a notice and comment rulemaking.

Case Study: Section 7 and Platform Removals in the Gulf of Mexico

More than 4,000 oil and gas production platforms dot the coastal waters of the United

States, most of them in the Gulf of Mexico, where the earliest structures were placed in the 1950's (MMS, 1985). The MMS projects that 2,000 structures will be scheduled for removal over the next 20 years, at a rate of about 60 to 120 per year (MMS, 1987). The waters of the Gulf of Mexico also are home to five species of threatened or endangered sea turtles, six species of endangered whales, and numerous protected marine mammals.

Given the 25- to 30-year average lifespan of offshore oil and gas structures, many of those in the Gulf are presently abandoned or targeted for abandonment and removal. Removal generally is accomplished by use of explosives, which are used to sever the well conductors and pilings anchoring the legs. Since all parts of the structure must be removed to 15 ft (4.6 m) below the ocean floor, other removal techniques, such as cutting by divers, have been found to be either too dangerous or ineffective. Attention was drawn to platform removal practices when it was made clear that several species of endangered sea turtles use as feeding grounds the highly productive shallows off the Texas-Louisiana coasts–an area that is home to most of the oil and gas production platforms in the U.S. – and that the type of explosions used in removals could injure or kill turtles in the area.

Chronology of Events

In the spring and summer of 1986, the NMFS reported unusually large strandings of marine turtles, mammals, and fishes along the upper Texas and southwest Louisiana coasts. The agency, which documents strandings, noted in reporting the event that some of the strandings occurred during a period when the offshore petroleum industry was engaged in using explosives to remove platforms no longer in production. The Service expressed in internal memoranda particular concern over the presence ot large numbers of the extremely endangered Kemp's ridley sea turtle (NMFS, 1986). After inquiries, the agency drew a connection between the strandings and rig removals in the Gulf and initiated an informal consultation with the MMS (NMFS, 1986). The agency also conducted experiments in cooperation with one company removing a rig and determined that, in fact, turtles in the vicinity of underwater blasts would be killed or rendered unconscious depending on their proximity to the explosion (NMFS, 1986).

In July, conservation groups contacted both MMS and NMFS to determine whether formal Section 7 consultations would take place and under what permitting authority the lethal experiments had been conducted. After determining some irregularities in the permit and discovering reluctance on the part of both agencies to initiate a formal Section 7 consultation, one organization contacted several oil companies planning rig removals in the Gulf and requested that they delay removals until a formal consultation could take place.[2] Two of the three companies planning imminent removals postponed them in response to the requests. The President's Council on Environmental Quality (CEQ) called a meeting on August 27, 1986, so interested parties could discuss the issues. A week before that meeting took place, the MMS Gulf of Mexico OCS Region Office requested operators in the Gulf to give advance notice of platform removals in order to facilitate a cooperative monitoring program by MMS and NMFS (MMS, 1986).

Representatives of the Offshore Operators Committee, a group representing oil and gas companies operating in the Gulf; the National Ocean Industries Association; explosive contractors; Department of the Interior, including Minerals Management Service, Fish and Wildlife Service, and Office of Environmental Program Review; Department of Commerce, including National Oceanic and Atmospheric Administration and National Marine Fisheries Service; the Army Corps of Engineers; the Center for Environmental Education; and Greenpeace met at CEQ. Both industry and the MMS continued to express reluctance to initiate a Section 7 consultation of any type, while the NMFS indicated its willingness to continue with informal consultation, evaluating each removal on a case-by-case basis. Representatives from the public interest groups expressed the view that initiation of the formal consultations was no longer a discretionary matter, but a requirement of the ESA. The MMS maintained that there was insufficient evidence to connect the turtle strandings with platform removals using explosives, and industry representatives stated their concern that Section 7 consultations would cause delays and might in fact inhibit the gathering of data needed to determine whether rig removals actually did pose harm to endangered species.

Although the meeting ended inconclusively, a week later the MMS notified the NMFS that it had concluded that a "may affect" situation existed for endangered and threatened marine turtles during platform removals involving explosives, and requested that (1) the issue of platform removal be included in an upcoming Gulf-wide consultation preparatory to scheduled lease sales and (2) that expedited formal consultation take place in response to each identified platform removal on a case-by-case basis. The NMFS concurred in the finding. The two agencies met several times over the next few months, hammering out a set of guidelines for conducting the consultations and identifying procedures and techniques for gathering and exchanging data, advance notification on removals, monitoring, and mitigation.

Expedited Section 7 Consultations

The first consultation under the expedited regime was initiated by MMS after Cities Service sought approval on November 10, 1986, to use explosives in a platform removal. The MMS findings, after reviewing the proposed removal plan, were forwarded to the NMFS on November 19. By November 25, NMFS had prepared a 14-page biological opinion with a "no jeopardy" conclusion, proposed mitigating measures to reduce the likelihood of injury or death to sea turtles, and specified an incidental take of one Kemp's ridley and one loggerhead turtle. As the Act requires in such a statement, reasonable and prudent measures were delineated. These included sonar scans to determine the presence of turtles in the platform area, use of scare charges, delay until sea turtles observed in the vicinity had vacated, staggering of charges, postdetonation underwater inspections by divers, and a summary report. The platform removal was conducted according to the stipulated conditions and without incident (Montanio, personal communication, 1987).

The second consultation was requested on January 28, 1987, for removal of a Pennzoil platform in Federal waters off Louisiana. In this removal the company also proposed testing an embrittlement technique using liquid nitrogen followed by mechanical impact. On February 26, the NMFS issued a biological opinion with a "no jeopardy" finding. The reasonable and prudent measures specified in the incidental take statement, in addition to the same conditions imposed on the Cities Service removal, included a stipulation to use the embrittlement technique on all four pilings if it proved successful in the test.

The third consultation took place for removal of a damaged well conductor offshore of Galveston Bay, Texas. Exxon requested approval to use explosives on January 16, the consultation was initiated by MMS on February 25, and the biological opinion was issued by NMFS on March 27. By this stage, the agency began incorporating by reference the data and findings it had developed in the first two consultations, and the "no jeopardy" finding and incidental take statement had taken on the form they were to reflect in the following months for more than 20 applications from companies proposing to use explosives to remove platforms.

The length of time between the date of the request from the companies to the issuance of the biological opinion since then has ranged from as short as 7 weeks to as long as 33 weeks. Most of the consultations have taken around 20 weeks from initiation to completion. In most cases, the companies have requested approval far in advance of the planned removal date, so the development completion of the biological opinions has not significantly delayed actual removal of some platforms (Montanio, personal communication, 1987). However, oil companies point out that only 10 platforms were actually removed from September 1986 to mid-October 1987, a period when 96 proposed removals were pending, and that of 77 approvals issued between September 1986 and October 1987,65 were not issued until after June 30, 1987.

Where the first three biological opinions went into some detail, subsequent documents, by incorporating the prior information, have summarized in four pages the finding of "no jeopardy,'' the incidental take statement, and the conditions for use of explosives. Those conditions at present appear to be standardized as follows:

1. Approved NMFS observer monitoring prior to, during and after detonation on charges.
2. Delay ofdetonation until any turtles observed in the area (within 1,000 yards [914 m]) can be removed.
3. Detonation only during daylight hours.
4. Pre- and postdetonation surveys by divers, including recovery of any injured or dead turtles.
5. Staggered firing of charges.
6. Submission of a summary report.

Additional conditions that have been required, depending on particular circumstances of the rig location, size, and structural characteristics, have included aerial surveys before detonation and the use of acoustic devices to monitor shock amplitude and impulse. The required use of sonar scan was dropped early after it was determined to be ineffective in confirming the presence of turtles in an area. In those removals where the likelihood of turtles in the vicinity was very low, or where the size of the charges to be used was small, the aerial survey requirement has been waived, and the timing requirement has been relaxed from limiting detonations to within two hours after sunrise/before sunset to one hour after sunrise/before sunset.

Concurrent with the expedited consultations, the MMS began work on a programmatic environmental assessment (PEA) to address the general question of structure removals and to assess in one background document the spectrum of potential impacts associated with the removal of structures (MMS, 1987). While the PEA incorporates the measures that have been developed in the course of the case-by-case consultations, it also provides that specific environmental assessments should be performed for specific structure removals, using the PEA as the principle reference document (MMS, 1987).

Present Situation

By early November, one biological opinion was yet pending on a consultation initiated in September by MMS. The NMFS and MMS are reviewing the consultation procedures and requirements set out in the incidental take statements in an effort to become yet more flexible in their approaches to reasonable and prudent measures. For example, the agencies are considering allowing around-the-clock removals if a 48-hour preblast survey indicates there are no turtles in the area or if they can develop means to detect turtles at night. They also are reviewing potential avenues of research inquiry that will directly address the platform removal issue–for example, an assessment of distribution and abundance of the various species, the correlation of turtle sightings with specific rigs, methods for scaring turtles from the vicinity of a planned blast, or nonlethal alternatives to the usc of explosives in the removals.

In the case of the association of turtles with rigs, it is now postulated by NMFS scientists that loggerhead turtles may actually be resident at specific structures (Henwood, personal communication, 1987). While no hard evidence exists to confirm this, a review of existing information suggests a strong correlation. If such a relationship could be confirmed, the agencies could use different removal approaches for those rigs that are known to have resident turtles and relax requirements for those known not to have resident turtles.

The other recent development in the removal process is the planned application by several oil companies for a "small take exemption" under Section lo of the MMPA. Heretofore, each incidental take statement specified that it did not cover the taking of protected marine mammals. While the chance that dolphins might be in the vicinity of the platforms without being observed is very small, it has been suggested that the offshore operating companies might apply for the small take exemption permit to avoid any liability for incidental takings of marine mammals during platform removals (Montanio, personal communication, 1987). If such a permit is applied for, it would have to go through the notice and comment rulemaking process described above.

Finally, a Gulfwide, formal Section 7 consultation was initiated on January 13, 1987, preparatory to proposed Lease Sales 113, 115, and 116. Structure removals were included as part of the entire consultation on impacts of the proposed sales. Until the NMFS issues a biological opinion on removals using explosives, the expedited, case-by-case consultation will continue (MMS, 1987). The NMFS has said it cannot make a conclusion with regard to generic platform removal stipulations until more information is gathered or until industry develops nonexplosive cutting technology that can be widely applied. Therefore, biological opinions and review of platform removal proposals will have to continue through the expedited, case-by-case procedure (Creel, personal communication, 1987).

Discussion

As in any environmental issue, the players in the turtles and rigs event quickly chose numerous adversarial roles. The interests, however, were not as simple as "industry vs. environmentalist" or "industry vs. government." Here was a case where more than one element of a large and diverse industry was involved: actual owner/operators of the platforms were required to remove the rigs, yet also were required to comply with the ESA, while marine demolition companies, traditionally on the same "side" as the offshore operators, found that they would suffer substantial economic harm through the delays. The government, too, found itself with different interests: the MMS had to go forward with an activity in fulfillment of a regulatory requirement for platform removal, while both MMS and NMFS were obligated to fulfill their respective duties to protect endangered species. Even the environmental community had competing interests. The discovery that rig demolitions might be related to turtle deaths was made while conservation groups were locked in intense negotiations with government and the shrimping industry predicated on the fact that shrimp trawls were principally responsible for the continuing decline of endangered marine turtle species. The rig removal controversy was cited by shrimpers as proof that they were not the sole cause of the population declines. Even Rigs-to-Reefs advocates were not quite sure on which side to ally themselves: would the Section 7 consultations delay or inhibit the use of structures as artificial reefs?

The controversy that resulted when conservation organizations invoked the ESA began with many interests taking hard-line positions at opposite ends of a spectrum. Yet accommodation ultimately was reached. Platform removals resumed, no turtles have been known to be harmed, and the requirements of the law appear to have been met. On the downside, however, were the economic consequences for companies that actually conducted tbe demolitions of platforms in the Gulf and *were* delayed *in* realizing the income attached to that activity. In some cases, the oil companies had to wait months to proceed with removals of platforms for which they continued to assume liability. For the conservation community, however, the most important result was that implementation of procedures set out by law has demonstrated that the ESA actually can be made to work not only to protect endangered species, but also to allow the continuation of activity in areas where endangered species occur. While most of the parties involved agree that the process was somewhat slow in getting started, they concur that it is working, and cooperation on all sides has been commendable.

As mentioned above, concurrent with the exploration of the relationship between explosive removals and large strandings of marine animals, the MMS was engaged in seeking comment on revising its regulations as they applied to platform removals. At least one commenter suggested inclusion of advance notice and other elements of the MMS/NMFS guidelines in the final rule.[3] As of this writing, no final rule has been promulgated on the inclusion of the new Subpart I in the agency's regulations set out at 30 C.F.R. 250, and it remains to be seen whether the turtles and rigs controversy will have any effect on the way the final rule requires that platforms be removed.

Afso unknown is what the agency will do with the comments it solicited regarding the idea of leaving rigs in place. Since that request for views was not an advance notice of a proposed rule orregulatoryrevision, the only certainty is that the agency cannot act on the comments until it makes an actual proposal to regulate Rigs-to-Reefs. Indeed, in its programmatic environmental assessment on rig removals, the MMS notes that in order for it to have *an* option to allow structures to remain in place, regulatory revision would be necessary (MMS, 1987).

In studying the options for use of abandoned platforms, the National Research Council recommended that Interior "adopt a more flexible policy on platform removal, one that allows for case-by-case consideration of what is best in terms of cost, environmental impact, and public benefit."

If there is anything the rigs and turtles controversy has illustrated, it is the aptness of this statement. The recommendation could have been taken from any number of discussions by the conservation groups urging the use of the Section 7 consultation to protect endangered turtles. Such flexibility, if it allowed leaving some structures in place, could serve not only the interests of fishing enhancement and the interest of cutting the costs associated with removals, but also the desire to conserve marine species that have been shown to be adversely affected by the use of explosives in their environments.

The programmatic environmental assessment points out potential impacts associated with the alternative of leaving rigs in place. These include negative impacts, such as the effects on military traffic in the Gulf, hazards to commercial navigation, and the general issue of liability and maintenance on the rigs. These are questions that need to be answered, but right now MMS cannot really ask the questions, since as a matter of regulation, the agency *has no option* to leave a structure in place.

As information is developed in the course of the consultations and over experience with numerous, monitored platforms removals, it could lend support to the Rigs-to-Reefs concept. For example, if certain types of structures emplaced in waters of certain depth are found to be loggerhead turtle resting places, such structures might be candidates to be left in place. However, if a differently located/configured platform was found to have no turtles in its vicinity, removal of such a structure might be able to proceed with more relaxed guidelines for the use of explosives. These kinds of findings, in combination with the safety and liability considerations noted above, could all aid decisionmakers in selecting the best structures for use as artificial reefs.

At present, however, the information gaps are more numerous than the findings, and the regulatory mandate for removal does not allow much room for alternatives.

It is up to the MMS to integrate more effectively its missions of fostering the development of offshore energy and conserving marine resources and its recent policy of encouraging the use of obsolete petroleum structures for fishery purposes by initiating the type of regulatory flexibility urged by the National Research Council.

It is up the NMFS to foster the kind of research documentation that enables selection of particular platforms as artificial reefs or allows their removal by the most efficient and cost effective means. It is up to other government agencies with authority for permitting the use of structures for artificial reef purposes to employ the same flexibility, as well as to recognize that endangered species conservation duties and benefits also can be realized in the process.

As the case study illustrates, there are instances where diverse and contrary interests can come together to resolve conflicts. Alternative options for the use of obsolete petroleum structures may be a case where diverse interests can not only resolve conflicts, but can realize valuable opportunities in marine resource conservation and enhancement as well.

Notes

[1] The OCS Act, though a separate statute, generally is combined with the Submerged Lands Act in a "package" of law governing activities offshore. The latter reserves jurisdiction to the states for the waters and the seabed out to 3-10 miles. Platform removal activity in these state waters is overseen by the Army Corps of Engineers and, while the same principles apply, will not be discussed in detail in this paper.

[2] Center for Environmental Education, 1986. Letters from R. E. McManus to C. Garvin, Exxon Corp., July 31, 1986; to J.L. Ketelson, Tenneco, Inc., and G. M. Keller, Chevron Corp., August 8,1986.

[3] Center for Environmental Education. 1986. Comments on proposed rules for platform and structure removal in the OCS, from R. E. McManus to D. A. Schuenke, Minerals Management Service. Sept. 15, 1986.

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From **Offshore Oil to Offshore Fishing**

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In 1982 Tenneco faced the need to dispose of an obsolete oil production platform in the Gulf of Mexico off the coast of Louisiana. Such platforms are normally removed, hauled to shore, and cutup as scrap.

But the beneficial effects of the presence of such structures on marine life has long been known. Offshore platforms serve as steel reefs by providing shelter and support for numerous forms of marine life. Indeed, Japan has long used artificial reefs to enhance marine fisheries.

With this example in mind, Tenneco offered the platform to the State of Florida for use as an artificial reef that would benefit the marine life chain, enhance sports and commercial fishing, and provide researchers a point from which to observe marine life.

Large holes were cut in the structure to facilitate the movement of fish and to provide the maximum possible amount of surface area for barnacles and other marine life. The platform and its support jacket were then lifted on to a barge, towed to a site 20 mi (32.2 km) south of Pensacola, and installed in 180 ft (54.9 m) of water.

The following year Tenneco revisited the site and found it teeming with marine life. Local charter boat operators estimated that 12 to 20 short tons (10.9 to 18.1 metric tons) of amberjack alone had been caught off the artificial reef during the first nine months after it was installed. The project was a success. Tenneco had pioneered the concept of using obsolete oil platforms as artificial reefs.

In 1985, three more Gulf of Mexico platforms were scheduled for removal. The State of Florida requested that they be installed as an artificial reef approximately 1mi (1.6 km) off the shore of Miami and Ft. Lauderdale. Three platform decks and two supporting jackets were towed 790 mi (1,271 km) to the site, The decks were installed in 100 ft (30.5 km) of water--accessible to divers--and the two jackets were installed in 200 ft (61.0 m) of water to benefit fishermen. The complex is now the largest artificial reef in the United States.

The success of these projects has encouraged Tenneco to seek other ways to make its operations harmonious with the environment. In addition, the company has worked to further the use of artificial reefs. Tenneco supported the U.S. Congress' passage of the Fisheries Enhancement Act of 1985, which encourages the development of additional reefs. The company raised funds for Congressional receptions, testified at hearings, and worked with Congressional staff members to draft language for the bill. The company has supported studies to determine the economic and ecological benefits associated with artificial reefs.

In addition, Tenneco has actively supported the Artificial Reef Development Center, has assisted the Gulf of Mexico Fishery Management Council in studying the red snapper population, and has assisted in experiments to determine whether explosives used in platform removal harm marine life.

Dr. Michael Zagata is Director of Environment and Safety at Tenneco, Inc. He was born and educated in New York, where he gained undergraduate and graduate degrees in the biological and physical sciences. He earned a doctorate in wildlife ecology from Iowa State University. Dr. Zagata has worked as an educator in academia, as an administrator and public relations director for national conservation organizations, and was formerly associated with the National Academy of Sciences.

Early Fish Assemblages on Tenneco II Reef, South Florida

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Introduction

Nearshore placement of obsolete petroleum platforms in the Atlantic Ocean off Miami-Fort Lauderdale, Florida, in October 1985 afforded an opportunity to document the fish community associated with these redeployed, submerged structures. Five sections of rigs were towed via barges from the northern Gulf of Mexico and placed, at the expense of Tenneco Corporation, approximately 2 mi (3.2 km) off the coast, at depths over 100 ft (30.5 m). The project described here was undertaken to determine the diversity and distribution of finfishes associated with this artificial habitat within one year of placement. A summary of these results is accompanied by observations on improving and understanding tbe contribution of rigs-to-reefs habitat enhancement.

Although the flora and fauna of actively operating offshore platforms have been described scientifically, no ecological research on redeployed structures has been published or apparently even conducted. Thus, although there is a substantial database for at least certain geographic areas of oceanic oil and gas production, environmental predictions concerning the role of platforms relocated specifically for fisheries enhancement remain unsubstantiated. Such data are essential in making decisions for the whole rigs-to-reefs effort.

The unique nature of this research warranted extensive logistic preparations for data acquisition. This work is reported in more detail in the final report to Tenneco, and additional scientific information (e.g., life history, literature review) is provided in a manuscript submitted for journal publication.

Methods

Intensive field sampling was conducted August 3-7, 1986, using nondestructive techniques to determine abundance and distribution of fishes associated with decks, understory, and supporting jackets at the two shallowest and shoremost locations. Repetitive transects with video cameras were conducted at three depths (60, 80, and 100 ft [18.3, 24.4, and 30.5 m]) and three times of day (first morning light, midday, and last evening light) to quantify fish abundance. At each depth and time, horizontal transects were made linearly along the perimeter of the platform and across its interior, and in a circle at the corners.

An initial site reconnaissance and a later trial of field operations had revealed the physically-demanding conditions likely to be present at the site, which dictated judicious planning. The ocean environment was influenced by reversing and sometimes rapid Gulfstream currents, and repetitive dives had to be planned to 100 ft (30.5 m) to sample all microhabitats.

Analysis of videotapes confirmed our expectation that under varying conditions resolution of different size fishes in the field of vision also varied. Thus, out of the pool of species observed on the rigs, a reduced number (18) were designated for quantification from taped transects. These were forms with distinctive shape or size (for the stage of the life cycle present at this time of year) that could always be recognized at the species or genus level. In this subset 11 forms were always identified to species. Because of sport and commercial interest in the reefs, 6 fishes were identified as target species for closer analysis of distribution patterns.

An interinstitutional team was assembled for the fieldwork. A commercial dive boat was chartered and positioned over the two rigs in a three-point mooring for the summer study period. Faculty from the dive technology program at Florida Institute of Technology (FIT) coordinated diving, which included surface supply, mixed gas scuba, and oxygen decompression operations. Staff from the Academic Diving Program at Florida State University supervised videography.

Because of needs to minimize costly at-sea time and safely maximize diver bottom time to acquire the desired number of samples, Nitrox gas mixture was used by the scuba divers on repetitive dive schedules. This enabled them to stay longer at depths of up to 100 ft (30.5 m) with no or reduced decompression. (Technical aspects of this part of the project were reported by D. Crosson of FIT to the 1986 annual meeting of the American Academy of Underwater Sciences.)

Data analysis included use of the SAS statistical software package. Analysis of variance techniques on a factorial model was used to test the effect of depth versus time for mean values of fish abundance. Followup pairwise comparisons were made with Scheffe's multiple comparison procedure.

Results and Discussion

A diverse fish fauna occupied the two Tenneco II reefs 10 months after deployment. From combined quantitative and qualitative observations on both rigs, 47 species representing 20 families were identified over the 4-day study period. Five of the six most speciose families are strongly associated with and typical of coral reef and other live bottom communities. Five species each of Labridae (wrasses) and Pomacentridae (damselfishes) were observed, followed by four species each of Pomacanthidae (angelfishes) and the more pelagic and mobile Carangidae (jacks). Three species each of Haemulidae (grunts) and Scaridae (parrotfishes) were observed. This level of diversity was similar to that on nearby shallow artificial and coral reefs close to shore.

From videotapes in which all forms could be identified, the most abundant two species (80 percent of observations) were the blue head wrasse (*Thalassoma bifasciatum*) and the bicolor damselfish (*Stegastes partitus*). Both forms are relatively small as adults and show strong site-fidelity with their habitat. Their abundance is coincident with amount of cover and relief. The latter clearly had established territories and defended them. Virtually all observations of both species were made only at the upper level of the platforms. While one of the platforms had only an upper deck (grated), the other contained decks (solid) at the upper (60 ft [18.3 m]) and middle (80 ft [24.4 m]) levels.

Among the larger and more distinctive fishes that could be recognized on tapes of lower resolution, a high proportion were of sport or commercial interest. Jacks (family Carangidae) accounted for 53 percent of all fishes observed on the seaward rig. The most abundant of all species was the bar jack (*Caranx ruber*); the amberjack (*Seriola dumerili*) also was common. Both are schooling, free-swimming species that are not strongly attached to the reef site, yet presumably they use it as a feeding site.

The next most common families were snappers (Lutjanidae), 24 percent; surgeon fishes (Acanthuridae), 13 percent; and barracudas

(Sphyraenidae), 7 percent. The latter family was represented by one species, *Sphyraena barracuda*. The grey snapper (*Lutjanus griseus*) was the second most abundant species. It predominated at the upper two levels on the rig, while the blackfin snapper (*L. buccanella*) was observed only at the lowest (100 ft [30.5 m]) level and in lesser numbers. Other groups represented by a few individuals, at most, included triggerfishes, angelfishes, and trumpetfishes.

Statistical analysis of the distribution of fishes counted along transects indicated that they are not simply random in time and space. However, it is not possible to specify the exact pattern of variation because of small sample size. Within the constraints of this pilot study, it is possible to discern a trend for target fishes to concentrate at middle depths and to be least abundant near the bottom. Inasmuch as these rigs were deployed on barren sand areas, lower population levels at the bottom might be expected. Also, minimal superstructure on the rigs existed there.

Notably absent from this habitat were groupers, which may eventually colonize the rigs. A follow-on survey could address this, Grunts were uncommon, possibly due to the absence of grassbeds nearby to support nocturnal foraging.

Qualitative observations of fishes off the rig, either in the open water column or on the bottom, were limited to occasional schools of scad (*Decapterus punctatus*). The degree to which scad might use these rigs for a behavioral cue or possibly feed in the vicinity is unknown, but this species certainly provides an abundant source of food for carnivores such as amberjack.

The two studied deck-and-jacket reefs offer a composite of habitats. The top deck (60 ft [18.3 m] deep) resembles an inshore live-bottom system with small, site-attached fishes and large mobile forms wandering in and out. Numerically dominant macro-invertebrates were sea urchins and spiny oysters. Under the top deck is a shaded area occupied by larger forms, including both less mobile species that inhabit the reef full time and free-ranging fishes that spend time away from the rig as well as swimming around its members.

From the standpoint of methodology, the use of Nitrox for scuba operations permitted 50 percent more dives in the repetitive schedule and saved a total of five man-hours of decompression. It was noted that divers on Nitrox were fresher physically after a day of diving. The three-point mooring enabled permanent television transmission lines and surface supply air hoses to be run to the rig, A safer and more technologically sophisticated field effort than might ordinarily be conducted was permitted in this pilot study.

Enhancement of Rigs for Fisheries

Of the rigs deployed off the U.S. it appears that perhaps 0.1 percent have been redeployed as dedicated fish habitat. Two considerations for the future use of rigs in fishery management are available. One is how they might be modified for biological purposes. For example, vast open interior spaces between jackets might be modified by fish aggregating devices of some sort, just as the decks might receive material such as cable coils to provide additional cover for forage species. Actual structure of the rig may influence fish populations, too. In general, the solid deck surface did not contain the diversity and abundance of fishes found onthe grated surface. This diversity may have resulted from a combination of factors. The grating afforded more hiding places for small fishes, thereby increasing the diversity of small species and also food supply for predatory species. Also, openingsin the grated surface would permit access to the upper surface for animals living in protected areas under the deck.

Secondly, deployment of rigs should entail ecological guidance on how placement might be directed to provide specific research opportunities. Forexample, turning onerigon its side–with decking perpendicular to prevailing current–for comparison to an upright unit might enable verification of Japanese observations on nutrient upwelling due to physical barriers rising from the seafloor. With the great potential of the rigs-to-reefs effort, a small investment in research and design offers high returns in terms of long-term fishery habitat enhancement.

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An Evaluation of Rigs-to-Reefs in Fisheries Development

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Abstract

The Tenneco II artificial reef in Florida resulted from the conversion of obsolete offshore petroleum platforms into an artificial reef complex. An evaluation of the Tenneco II project provided information on the efficacy of using obsolete petroleum platforms as artificial reefs for fishery development. The research results are grouped in three sections. The first section investigates the planning and construction of Tenneco 11 in the light of established artificial reef planning frameworks. In general, the Tenneco II project was developed according to the guidelines in the National Artificial Reef Plan and demonstrated the need for clear and cohesive project objectives when undertaking such public/private cooperative ventures. The second section considers Tenneco II reef siting decisions, The lack of formal siting procedures for the Tenneco II project resulted in some difficulties in determining appropriate locations for the reef structures. Given this need, a system for future Rigs-to-Reefs siting is described in terms of a coastal zone mapping process. The last section examines the socioeconomic implications of Tenneco II including measurements of use and economic values associated with the reef. Overall, local sport fishermen were willing to pay an average of $14.36 per individual for the construction of another reef like Tenneco II. Given the evaluation of Tenneco H planning, siting, and socio-economic benefits, implications for the future use of petroleum platforms as artificial reefs are discussed.

Introduction

Interest in the use of oil and gas structures as artificial reefs (Rigs-to-Reefs) has been encouraged through several demonstration projects supported by the oil and gas industry (Wilson, 1986). These large-scale artificial reefs have proven to be excellent fish habitat. But, while these projects have demonstrated the technical feasibility of deploying obsolete rigs as reefs, there is still a need for a more systematic, integrated approach to Rigs-to-Reefs as part of fishery development.

The present Tenneco H Rigs-to-Reefs study sought to assess fishery development and management information in three main areas: (1) reef planning and deployment; (2) reef siting for the recreational fishing industry; and (3) evaluation of reef use and economic implications for the fishing community.

Methods

The deployment of the Tenneco II artificial reef in the waters of Dade and Broward counties, Florida, presented an excellent opportunity to apply some previously developed planning, siting, and evaluative procedures (Ditton and Burke, 1985; Myatt and Ditton, 1985; Bockstael et al., 1985, 1986) to a specific Rigs-to-Reefs project (McGurrin, Phillips, and Radonski, 1987). Different research methodologies were used to evaluate each of the three major components of the study as follows:

Tenneco H Project	Research Methodology
1. Reef Planning and Deployment	A Case Study of Reef Development Decisions
2. Reef Siting	Resource Planning and Exclusion Mapping Procedures
3. Socio-Economic Implications	Mail Survey

Results

The results of the three phases of research are summarized below in terms of Rigs-to-Reefs as a tool for recreational fishery development.

A Case Study of Project Deployment and Planning

The 920-mi (1,408-km) transportation of three Louisiana platforms to south Florida began on September 27, 1985. On October 3, 1985, the total of two support structures and three platform decks were deployed from the barge at the Tenneco II reef site (figure 1). These structures were placed in depths ranging from 90 to 190 ft (27.4 to 57.9 m) of water and projected to not more than 60 ft (18.3 m) below the water surface (as specified in the permit). The entire reef site area was roughly one mile wide by two miles long. The total cost of the project, though not divulged by Tenneco executives, is believed to have been in the range of $500,000 to $1,500,000.

The deployment of tbe Tenneco H reef was the result of cooperation and compromise between public and private sector entities. The public sector was represented by the respective county government artificial reef programs. A competition between the two counties for the Tenneco H structures developed during the initial project planning stages, before a compromise was developed. A large reef site was chosen so that both counties could share in the use of the Tenneco 11 reef. It includes a permitted area that straddles the Broward/Dade county line.

From the private sector viewpoint, Tenneco's aim was to demonstrate tbe feasibility of the Rigs-to-Reefs concept as a cost effective means of recycling obsolete oil and gas platforms. Rather than use the traditional shore-based disposal of the platforms, Tenneco officials wanted to combine the creation of fishery benefits with the development of alternatives for corporate cost savings in the disposition of platforms. A number of different types of Rigs-to-Reefs options (leave postproduction structures in place, topple on site, etc.) may offer future cost savings for the company (Reggio, 1987), but the type of deployment option used in Tenneco II cost more than traditional disposal. Tenneco holds that tax credits to compensate for the additional costs are a necessary incentive for this type of Rigs-to-Reefs program to be initiated on a broad scale.

Reef Siting for Fishing Industry Development

The second objective of the study was to describe the importance of reef siting in creating an effective artificial reef. Given that formal siting methodologies can aid future Rigs-to-Reefs projects, the Tenneco 11 project was viewed in terms of "Resource Planning" procedures (McGurrin and Reeff, 1986), which combined factors that maximize the probability of recreational fishing use and minimize multiple use conflicts. The framework of resource planning was based on basic coastal zone mapping procedures (Myatt and Ditton, 1985) that (1) characterize the marine recreational fishing industry on both state and local levels, including identification of specific access facilities such as marinas and boat ramps and the approximate numbers of private boat fishermen making use of local access facilities; (2) determine priority recreational fishing zones (areas of high recreational fishing use); and *(3)* identify inappropriate reef siting areas (exclusionary areas) within these zones, including shipping lanes, live bottoms, traditional bottom trawling areas, military warning zones and marine sanctuaries.

When viewed in terms of resource planning information, the location of Tenneco 11 fits into a framework of maximizing benefits to the recreational fishing industry. Although formal resource planning procedures were not available at the time to guide the project siting, Tenneco officials intuitively chose an area noted for the importance of its recreational fisheries (Broward/Dade, Miami area). The reef site lies well within a major area of high recreational fishing use; adding to its attractiveness was the fact that exclusionary areas (marine sanctuaries, shipping lanes, etc.), identified as potential use conflict areas not suitable for artificial reef development, did not apply in this case.

Tenneco II Use and Economic Implications

The purpose of the socio-economic survey was to examine angler use, perceived fishing quality, and economic value of Tenneco II and other reef fishing areas in Broward and Dade county waters. Afewof the findings are highlighted below.

Survey results showed that 46 percent of the saltwater boat fishermen in the survey had spent at least "some" time fishing over artificial reefs in the study area. A somewhat smaller percentage of the sample, 41 percent, reported that they had fished over natural reefs. About 12 percent of all boat fishermen in the sample reported using the Tenneco 11 reef during the previous year.

Using the above information on artificial and natural reef fishing participation, anglers were classified into two groups: (I) artificial reef fishermen -those who had fished at least part of onc trip at *an* artificial reef during the previous year – and (2) nonreef fishermen – those who had not fished at an artificial reef during the previous year. Reefand nonreef fishermen were asked to rate the fishing quality at various artificial and natural reef locations.

Fishing quality ratings for all artificial reef and natural reef locations were not significantly different between artificial reef and nonreef users except for the Tenneco II site (table 1). Reefusers rated the Tenneco 11 reef higher in quality than nonreef users.

Artificial reef users and nonreef users also were asked to compare specific quality attributes of the Tenneco II reef as compared to other fishing locations (table 2). There were no significant differences between reef and nonreef users, except for ratings on two catch-related attributes. Reef fishermen felt that both the size and types of fish that could be caught at Tenneco 11 were better than at alternative sites.

Finally, anglers in the survey were asked to indicate how much they would be willing to pay for the construction of another reef similar to the Tenneco II reef. Overall, fishermen were willing to pay an average of $14.36 for another reef like the Tenneco II reef. As would be expected, artificial reef users were willing to pay more ($19.38) than nonreef fishermen ($10.00) for another artificial reef site. Itisinteresting to note that nonartificial reef fishermen indicated some willingness to pay for artificial reef development. This support may be based on beliefs that reefs may reduce crowding on traditional fishing grounds by providing new fishing areas or may be helpful to tbe fishery resource and provide more and better fishing in the future.

Discussion and Implications

Overall, the development of Tenneco II demonstrated the importance of public-private cooperation in developing future Rigs-to-Reefs programs. Broward and Dade counties, the State of Florida, the U.S. Army Corps of Engineers, local governmental officials, and the private sector, all made a special effort to facilitate the deployment of the reef. The planning of the project was efficient in terms of overcoming many of the obstacles in artificial reef development (permitting delay, liability concerns, etc.) and generally paralleled planning guidelines available from the National Artificial Reef Plan (U.S. Dept. of Commerce, 1985). The difficulties that occurred in the project were mostly centered on the site selection.

Because the specific site choice came out of a series of public and private sector negotiations and compromises, some of the problems associated with the site selection might have been alleviated by referencing formal fishery planning procedures. Although the resource planning and mapping methodologies were not available for the Tenneco II effort, similar siting procedures have since been adopted by the Louisiana Rigs-to-Reefs program. As part of this process, data on the potential of individual platforms as fish habitat, tfre expected lifespans of platforms (i.e., when production may cease), and various alternatives of rig disposition are merged with fishery development information (access facilities, fishermen use, etc.).

Finally, the Tenneco 11 experience highlighted the fact that Rigs-to-Reefs projects require extensive funding for construction, maintenance, and management. Industry and government have expressed an interest in supporting Rigs-to-Reefs, if they can justify the investment (Wilson, 1986). While this study involved only a cursory look at the socio-economic implications of Tenneco II, this kind of knowledge is essential in providing some of the justification for future Rigs-to-Reefs investments.

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Mr. Joseph M. McGurrin received a B.S. in biology from the College of William and Mary and an M.S. in fishery science from the University of Maryland. He was formerly associated with the Sport Fishing Institute in Washington, D. C., where he served as Director of the Artificial Reef Development Center. Currently, Mr. McGurrin is Recreational Fisheries Coordinator for the Atlantic States Marine Fisheries Commission.

Mr. Anthony J. Fedler is Assistant Professor, Department of Recreation, University of Maryland, College Park, Maryland, Mr. Fedler has worked on the socio-economic aspects of all types of recreational fisheries, As a graduate student under Dr. Robert Ditton at Texas A&M University, Mr. Fedler coauthored several papers on the use of petroleum platforms as fishing sites off the coast of Texas.

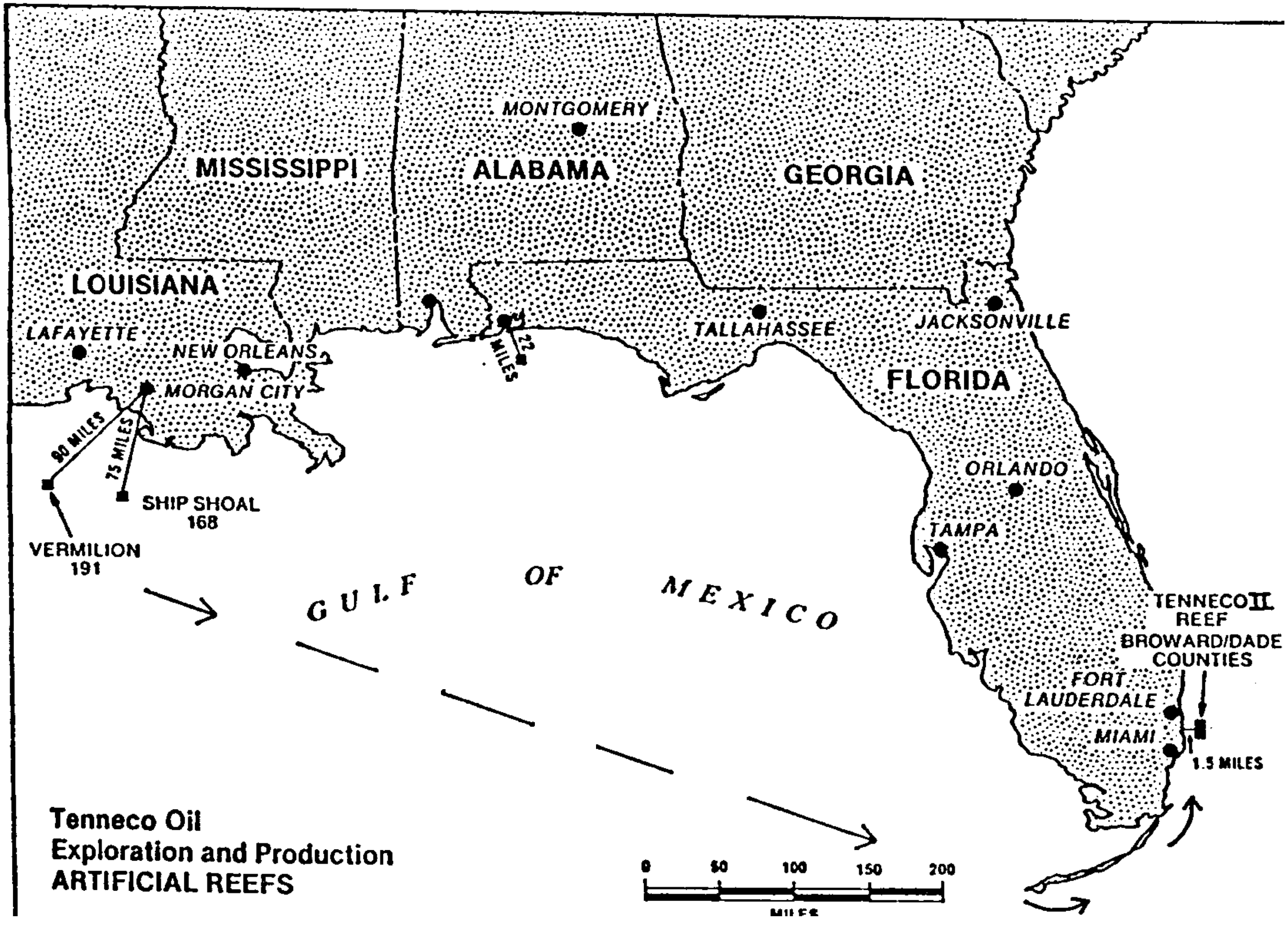

Figure 1. Transportation of obsolete platforms to Tenneco II reef site.

AS SUBMITTED BY AUTHOR

Table 1

Artificial Reef and Nonreef Angler Ratings of Fishing Quality at Various Fishing Locations and Areas

Reef Locations or Areas	Mean Rating* Artificial Reef Fishermen	Nonreef Fishermen	Prob.
Artificial Reefs South of Haulover Cut	3.1	2.8	ns
Artificial Reefs North of Port Everglades	3.1	2.9	ns
Mercedes Reef	3.0	2.8	ns
Tenneco II Reef	3.2	2.8	$p< 0.05$
Natural Reefs	3.3	3.2	ns

*Quality ratings were based on a 5-point scale ranging from (1) very poor to (5) very good.

Table 2

Artificial Reef and Nonreef Angler Quality Attribute Ratings at the Tenneco II Artificial Reef Versus Fishing at Other Areas

	Mean Rating of Quality Attribute Comparisons* Artificial Reef Fishermen	Nonreef Fishermen	Prob.
Overall fishing fun	1,69	1.73	ns
Number of fish caught	1.63	1.80	ns
Size of fish caught	1.63	1.91	$p < 0.05$
Types of fish caught	1.68	2.00	$p < 0.01$
Crowding while fishing	1.94	2.0	ns
Distance traveled for fishing	1.97	2.01	ns

*Quality rating comparisons between Tenneco II and other fishing sites were based on a 3-point scale consisting of(1) Better at Tenneco II, (2) No difference, and (3) Worse at Tenneco II.

Mariculture on Offshore Oil Development and Production Platforms

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Background

ECOMAR, Inc. is a marine consulting firm specializing in field oceanographic and marine biological studies over the past 13 years.

For the past 8 years, we have been developing ocean farming (mariculture) on offshore development and production platforms in the Santa Barbara and Catalina Channels.

Introduction

The predominant fouling organism occurring on California offshore oil production platforms is the mussel *Mytilus* spp. This shellfish, closely related to the oyster, scallop, and clam, is responsible for 80 percent of the growth *on* underwater platform structures. This prolific and abundant fouling "pest" is a gourmet food item, presently under intensive mariculture in at least 10 countries worldwide. Mussels are extremely efficient energy converters, capable of producing over 400,000 lb (181,440 kg) of delicious meat per cubic acre per year. Since the oceanographic climate in California and the configuration of offshore oil production platforms provide some of the most optimal conditions for mussel growth, we have been developing this resource to produce a viable, new mariculture industry and economic resource. There are significant advantages to the operators, advantages which not only include food production but also the eventual elimination of platform biofouling cleaning costs, new platform permit mitigation, enhancement of the public image of these offshore structures, and the potential elimination or delay of costly postproduction platform removal.

Current **Operations**

ECOMAR, Inc., has spent many hours over the past years studying the biofouling patterns on offshore platforms for operators in the Southern California Bight. These studies were the genesis of our mariculture program.

Through research we have found that the succession of fording animals on newly installed or recently cleaned platforms progresses in a predictable manner. The first hard growths are barnacles and certain calcareous worm tubes. These encrustations are followed by *Mytilus edulis*, the bay mussel. These mussels form a homogeneous coating two to four individuals thick within six to eight months after platform installation or cleaning. As time progresses, these initial settlers are outcompeted by the larger and more hardy mussel species, *Mytilus californianus*. *These* eventually form very thick fouling growths one to two or more feet thick and eventually become overgrown with anemones and other epizoic hard and soft growths.

Our present operations consist of removing mussels *Mytilus edulis* (when they reach the appropriate size), processing, sorting, and bagging for immediate distribution.

All of the equipment required for harvesting, sorting, and bagging is situated on the lower platform walkways and boat landings. The systems use rig air (150 lb per square inch [68.0 kg/6.5 cm^2], 50 cubic ft [1.4 m^3] per minute) except for a self-contained, diesel-powered, dive air compressor. Divers scrape the year-old mussel accumulations from all of the major members of the platform, As the accumulations are dislodged, they are conveyed to the surface by a large suction hose. They exit this system and are run through a cleaning and sorting machine. After a final hand-sorting, the mussels are bagged and placed in a 3,000 lb (1,360 kg) gross weight transfer bin. The bin and the crew of six are transported to and from the platforms by regular crewboat runs.

current production averages 10,000 lb (4,536 kg) per week and, while distribution is primarily centered in California, we also distribute to Washington, Arizona, and to Chicago. The success of the program is volume and efficiency dependent. Current production levels of 40 to 50 bushels (1,410 to 1,762) per day are marginally profitable. Various forms of automation are currently under investigation.

Through years of testing, we have had all of the platforms on which we operate certified by the California State Health Department as shellfish-growing areas.

Under our present arrangement with the operators, we are contracted to maintain the platform's underwater surfaces at a low level of fouling. This is essentially an open-ended term, continuous platform-cleaning contract with no cost to the operator. These contracts have specific performance criteria (e.g., no more than eight inches of growth shall accumulate at any time on more than 50 percent of the subsurface structure; photo/video tape inspection of specified support members is provided to verify and track fouling conditions).

This now-viable program produces approximately $50,000-75,000 of shellfish per platform every 16 to 20 months.

We are continuing to expand the potentials for the role of offshore oil and gas structures in mariculture by developing caged (tray) culture techniques for oysters, scallops, and clams. The latter two are in the development stages and still require research and development. Oysters, however, are a viable immediate addition that we are pursuing at present.

Over tbe past two years we have evaluated three species of oysters and tray culture techniques on one of our mariculture platforms. After evaluating growth rates, depth requirements, and markets, we have settled on the Pacific oyster *Crassostrea gigas*. This species grows to market size in about the same time as the mussels (14 to 18 months). We have planted approximately 150,000 seed in trays and will, in the coming year, out-plant approximately 100,000 more. Our goal is to have one million oysters in culture by the middle of 1990.

Expectations for 1990 are 15 platforms producing 1.5 million lb (680,400 kg) of shellfish annually. At these levels the platforms will produce a significant portion of the region's seafood.

The fisheries value of the platforms under mariculture is growing steadily, and their future potential is very significant. We now produce over 90 percent of tbe fresh live mussels grown in the entire state of California. Nationwide, the platforms account for approximately 10 percent of all mussels commercially harvested or cultured.

Locally, our current production represents a large fraction of the mollusc species landed. With the continued growth of our mariculture operations and the declining commercial fish catch, the platforms, in the not-so-distant future, will be a major factor in the local and regional fisheries.

The present and future value of the offshore platforms in the development of mariculture in the United States cannot be understated. America's coastal bays and protected inlets, amenable to classical mariculture activities, are either in use or are too polluted. To expand, mariculture must move offshore. Without the offshore oil and gas structures, the development of viable techniques and species amenable to the implementation of open-ocean mariculture would be severely handicapped.

The growth of mariculture and its expansion into the open ocean are imperative if we are to have continued supplies of fresh, quality seafood in the coming decades. The wise use of existing offshore structures will significantly enhance and help ensure the growth of mariculture.

Dr. Robert P. Meek has over 23 years of diving and marine research experience on both the east and west coasts of the United States and in the Gulf of Mexico, He worked with the Smithsonian institution in association with the Harbor Branch Foundation Laboratories where he was awarded a Presidential Internship to be their Chief Diving Biologist in charge of submersible biological operations. He logged in excess of 200 hours of submersible time to depths of 1,500 feet developing submersible research techniques and conducting biological characterization studies on artificial and natural reefs,

Dr. Meek has acted as Principal Investigator for ECOMAR on over 50 projects. As Program Manager, he has supervised all project phases--proposal development, program and equipment design, field research, data analysis, and biological and oceanographic survey studies throughout the United States, Over the past 10 years Dr. Meek has developed the first viable offshore mariculture operations in conjunction with offshore oil and gas facilities (in the Santa Barbara and Catalina channel locales) in southern California,

He is a member of several professional organizations, Dr. Meek received a B.S. in biology, and an M.S. and Ph.D. in zoology from the University of California at Santa Barbara.

Rigs-to-Reefs as an Alternative to Platform Salvage

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Abstract

The current downturn in the offshore petroleum industry, along with the turtle issue curtailing platform removals, has resulted in an opportune time for the Rigs-to-Reefs concept. The author has found an unprecedented interest from both commercial and political viewpoints for the first time since his original introduction to the concept over 15 years ago. Operators are listening carefully to offers that provide alternates to costly platform salvage operations; the Minerals Management Service (MMS) is being supportive of commercial venture ideas involving multiple use of platforms; service companies are excited about the possibility of new industries offshore; and unusual farm-in arrangements have become commonplace. These factors make the approach described in the paper not only possible but economically feasible.

The paper details how under current regulations an offshore platform no longer able to produce sufficient quantities of hydrocarbons to justify the cost of its continued maintenance can economically be left in place. A specific example is given including the expected income and cost.

Current Conditions

Current conditions are ripe for alternate usage of offshore platforms as never before. The reason appears to be primarily the downturn in offshore hydrocarbon activity resulting from tbe oil price drop of $30/barrel (bbl) to $10/bbl last year. However, several other related and unrelated factors have played an important role in creating the friendly environment.

The downturn has significantly reduced the number of operating drilling rigs (over 4,000 in the early 1980's to well under 1,000 in 1986) and all the associated support companies' business. Boats, offshore catering, helicopters, and whole support industries have had to live with 25 percent of the income they had grown accustomed to, while most of their overhead stayed about the same (i.e., debt service and equipment maintenance). With oil prices down, the operating companies are not only faced with less income but–the important consideration for this paper–many of the existing offshore production platforms have become uneconomical to operate. At $30/bbl, a 500-bbl-per-day platform provides the operator $15,000 per day to pay the pumper, his boat charge, the costs of the required painting and cathodic protection to maintain the structure, the pipeline tariff, the royalties, and costs for production equipment repairs, navigational aids, maintenance, etc., etc.

But at $10/bbl, the cost to operate the offshore platform can be more than the operator is receiving for the oil or gas he is producing. This basic factor has made an unprecedented number of offshore platforms available for salvage. Table 1 lists the 75 platform removal applications current on August 12, 1987. This table leads to the next factor, which has played an important role in enhancing the interest in alternate platform usage.

Turtle Issue

The next factor, which has recently impacted the attractiveness of Rigs-to-Reefs, is what the author has labeled the turtle issue. Much concern, as covered in Klima's work (1987), has been expressed regarding the damage to the marine life surrounding offshore platforms that occurs when the platforms are removed by conventional explosive techniques. It seems that we have now gone the full circle in which, from an environmental viewpoint, offshore platforms have gone from bad to good, Reggio (1987) has documented the importance of these structures to the present marine ecosystem in the Gulf of Mexico. A dilemma has resulted in that current regulations under which the platforms were installed require that they be completely removed (to five meters below the mudline) within one year after production ceases. On the other hand the National Marine Fisheries Service (NMFS) is obligated to bring charges against anyone who knowingly authorizes or carries out a process that will kill an endangered species. Several protected species are thought to inhabit the submerged protection of offshore platforms. Even of more concern to the author than the damage done at the instant of removal is the loss of the future generations of marine life that will not be born and sheltered in the protective arms of each removed platform.

The dilemma has been effective in slowing down the rush to remove platforms. Some have judged this to have placed an unfair burden on a struggling oil and gas industry. As discussed above, current prices either have made it too expensive to continue to operate the platforms or have decreased the economic life of the production, making removal necessary.

Explosives have been the routine method used in platform removal. Alternate methods are available but are normally much more expensive, and tbe beleaguered oil industry is hollering "uncle." On one hand, industry income has been reduced to the point where it cannot afford to continue to produce, while on the other hand it is being told it cannot use the cost-effective removal approach it has used forbears. This has led MMS, NMFS, and the oil companies to be very interested in any idea that can minimize the cost of ridding themselves of offshore platform liability and possibly leave the structure in place.

Solutions

Recently many smaller oil companies have found it possible to work offshore where in the past it had been too risky or just too expensive. Duetothe downturn in business, costs have taken a dramatic fall. The "farm-in'' has become routine. Itworks something like this: Company Ahasleased anoffshore block and received the right from MMS to explore for and produce oil/gas from the submerged lands in exchange for the payment of certain bonus monies to the MMS. Company A may have drilled exploratory wells, set a platform, laid a pipeline, drilled the development wells, and begun production, or it may have only the lease when Company B approaches it and says in essence "I'd like to sharecrop for you." Company B can take over or assume a 100 percent assignment of theproperty (with MMS approval). In this manner the smaller company can work offshore at a much smaller risk (i.e., the oil/gas field may be already discovered and production facilities in place). Onthe other hand, the larger company with its larger overheads maynotbe able cooperate the platform, as noted above, and make an acceptable rate of return.

Oil companies are also selling "new but not abused platforms "as is, whereas." In other words, if someone is willing to pay the cost to remove the platform and assume plug and abandonment responsibilities, he can usually have the platform for use possibly at another location at a fraction of the original cost of the structure and equipment.

Whatever the option to conventional platform removal, oil companies are now more inclined than ever before at least to listen. Multiple uses such as Meek's commercial mariculture farming of West Coast platforms (Meek, 1987) are being tolerated by oilmen. In the not-too-distant past, multiple use would probably not even have been considered.

In addition to reuse or multiple use of existing oil/gas production platforms, a surge of interest in placing new structures in the ocean for other uses has been noted (i.e., Davis' Florida offshore casino). Many alternates to oil and gas are economic offshore ventures, but right now under current regulations *no* Federal Governmental agency is available to license these commercial ventures. Much effort has been expended toward this end, but the fact remains that none exists. It is the author's opinion that political/commercial/regulatory/environmental interests are presently tuned in to the desirability of extending the U. S.A.'s development offshore as no time in the past.

Catch 22

If all the above interest is real and if many companies and individuals have attempted to start new industries on offshore platforms in the past, why hasn't it happened? The one element mentioned above, namely that no governmental agency is available to license such ventures, has in the end discouraged these developments. No one has been willing to invest the millions required to start an offshore venture without a written assurance from the government that it is acceptable, and no agency within government has the authority to do so. The MMS can grant leases for mineral exploration/production/related activities but for no other purposes. The U.S. Army Corps of Engineers can grant permits for artificial reefs, but as much as the MMS would like to, it cannot currently allow an offshore platform to remain intact as an artificial reef.

With the above in mind, the author and a group of interested parties developed a scheme by which all parties can be satisfied and a venture other than oil/gas can be carried out on an offshore platform. Actually, the approach is not new; the West Coast mariculture project cited above is an example of how it can be done. The following sections describe a real venture that was carried through to the firm proposal stage.

Sample Venture

The key to a successful alternative (to oil/gas/mineral exploration/production) offshore venture under today's laws in the U.S.A. is to continue to produce oil/gas while also doing the other venture. Multiple usage becomes the key. This idea was shared with three MMS Regional Supervisors (Leasing & Environment; Field Operations; and Production & Development) last fall and was encouraged. A group of individuals primarily involved in service companies supporting offshore operations, along with a person sensitive to environmental concerns, a person sensitive to political concerns, and a person with expertise in the alternate venture, was approached by the author. The enthusiasm of this loosely-formed group was enough to dare to approach a major oil company to see if the idea would be seriously received. This major oil company had an offshore complex of two platforms joined by a bridge, which they were expecting to become a candidate for salvage in the near future. The structures are only about six years old. Complete gas production facilities and utilities to support up to about 20 personnel rested on the platform. The 100 MMcfd field had depleted to a noncommerical 1.5 MMcfd production rate and the major oil company could no longer justify the expense of maintaining the structure and equipment. A presentation of the group's venture idea was made to the major oil company.

In a nutshell, the group proposed that the major oil company transfer the entire property to the group. The cost to the major oil company would be far less than the abandonment and salvage of the platform and wells. The group would continue to produce the small amount of natural gas and sell some to the pipeline and use some for the venture utilities. The group would enhance the existing facilities to serve as a base for scuba diving and fishing. The expected attraction to the public is that the heliport makes the site less than a l-hour helicopter ride from Freeport. Freeport is already *a* jumping-off point for many offshore fishing and scuba trips. No longer would the public have to waste a majority of their entertainment time in the long boat ride to clear water and good fishing. Even more attractive is the thought that people would not be seasick when they finally got on location.

The major oil company listened attentively to the presentation. Two concerns were expressed (1) How could they be assured that future liabilities for their company could be eliminated? and (2) Would it be possible to obtain insurance coverage to handle the tourist and production simultaneously on one offshore platform complex?

After this initial meeting, these two concerns were addressed in earnest. First, it was found that "farm-ins" routinely gained 100 percent of an offshore property. Sometimes the company assigning the property even paid the assignee to take the property as part of the terms of the agreement. The land department of the major oil company had no problem with a 100 percent assignment of the property in question as long as it was to its best interest *and* MMS would look favorably on the assignment. The MMS must be convinced that the new operator is reputable. One key element in this judgment is a $50,000 bond that must be posted naming the MMS as the beneficiary.

The second concern was more easily addressed, as one of the group members is an insurance broker dealing in offshore coverage. This matter was handled by obtaining quotes for the coverage required for the multiple usage.

Shortly after these concerns were addressed, the major oil company allowed the group to visit the site and then, along with several other companies interested in the property, to submit a formal proposal. The next section describes the venture group and its interests.

Venture Group

A broad spectrum of interests makes up the venture group. It was the author's intent to involve individuals with complementary expertise and company affiliation that are necessary in implementing the venture. Dana Larson of The Rigs-to-Reefs Company provides oil/gas experience along with a keen interest in environmental concerns. Jim Shaw of Houston Helicopters is a key member due to the importance of the helicopter in making the venture go. Mike Price of Houston Scuba Academy provides the marketing and alternate venture expertise. John Mahony of Universal Services represents the offshore catering viewpoint. Jerry Deere, Republican Party chairman and chairman of the Rigs-to-Reefs committee of the Brazosport Chamber of Commerce, provides political insight. John Johnson of Oceaneering International is knowledgeable in subsea maintenance and platform salvage. Tom Knapik of Jardine Emett & Chandler

Insurance Brokers gives insight into insurance needs. The author's company, Petro-Marine Engineering, provides the project management and engineering skills necessary for the venture. Finally, Mike Doughty of Occidental Energy Company agreed to be the oil/gas operator for the group. The author's brother John (an oil/gas service company lawyer) provides legal advice.

The group was very excited about the possible venture. When it was formally invited to make its proposal, this excitement turned to the serious business of economics.

Venture Economics

Before a viable offer could be made, it was necessary to carefully examine the realistic costs and project the expected income to the venture. In addition, it was necessary to establish which of the group members wished to be partners in the venture and which only wanted to provide a service to the group. Year 1 expenses and income estimates were developed using the group's expertise. A summary of these projections is given in Table 2. As shown, a $130,000 profit is projected during the first year of operation *if* the major oil company pays the group to take the property off its hands *and* certain group members contribute approximately one-half of the value of their services to the group in payment for a prorated share of the ownership of the venture. The individual contributions and resulting ownership percentage are not indicated for obvious reasons.

The following year's expenses and income are projected in Table 3. As shown, the projected profit continues to be approximately $130,000 each year. When considered as a percent of gross income, the profit is not especially attractive. However, if considered in light of the political, environmental, and public service return, it seems quite attractive to the author.

Summary

This paper presents a method whereby under current laws an alternate commercial venture can be established on an offshore platform. Although the sample venture was unsuccessful (the major oil company decided to relocate the facility to another location for its own use), the exercise showed that such a venture is certainly feasible.

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Table 1

Applications for Platform Removal

8/12/87

Company Name	Date Received & Approved	Lease No.	Area Block	Platform Name	Proposed Date for Removal & How	Water Depth
1. Cities Service	11/29/86	OCS-G 3374	GA 144	B-1 (25x25)	11/86 Explosives	48’
2.3 Exxon	n/14/86	Ocs 019	ST 54	c (11OX95,)	3187 Explosives	65’
3. Pennzoil	12/29/86 2/27/87	OCS-G 2078	VR 228	A (64x72)	1/87 Explosives& Liquid Nitrogen	126’
4. ODECO	1/14/87	Ocs 043 Ocs 046	EI 88	3 (20x20x20) 4	5187 Explosives	18’
5. ODECO	1/14/87	Ocs 043	EI 88	4&9 (20x20x20)	5/87 Explosives	18’
6. ODECO	1/14/87	Ocs 043	EI 88	5 (36" caisson)	5/87 Explosives	18’
7. ODECO	1/14/87	OCS 0312	EI 27	4 (96" caisson)	5/87 Explosives	17.5’
8. ODECO	1/14/87	Ocs 043	EI 88	8 (48’ caisson)	5187 Explosives	15′
9. ODECO	1/14/87	Ocs 043	EI 88	6 (36" caisson)	5187 Explosives	18’
10. ODECO	1114/87	OCS 0312	EI 27	9 (96" caisson)	5187 Explosives	18’
11. Exxon	1/20/87 4/08/87	OCS-G 6168	HI 196	I (48" caisson)	1/87 Explosives	53 ‘
12. Tenneco	1/20/87 6/11/87	OCS-G 2927	ST 59	A (70x70)	Early 1987 Explosives	83′
13. Shell	1/27[87 6/26/87	OCS-G 4390	WC 167	1 (48" caisson)	4/87 Explosives	47′
14. Shell	1127187 6/26187	OCS-G 4390	WC 167	2 (48" caisson)	4/87 Explosives	47’
15. Shell	1/27187 6126187	OCS-G 5072	SA 14	1 (48" caisson)	4/87 Explosives	31’

(continued)

Table 1

Applications for Platform Removal

8/12/87

Company Name	Date Received & Approved	Lease No.	Area Mock	Platform Name	Proposed Date for Removal & I1ow	Water Depth
16. Texas	2/03/87	OCS-G 1182	SM 11	1(84" caisson)	7/87 Explosives & Cutting Torch	71'
17. Texaco	2/03/87	OCS-G 1182	SM 11	H (84 caisson)	7187 Explosives & Cutting Torch	71'
18. Texaco	2/03/87	OCS-G 1182	SM 11	48 (66" caisson)	7/87 Explosives & Cutting Torch	71'
19. Texaco	2/03/87	OCS-G 1182	SM 11	14& 20 (36x36x36)	7/87 Explosives	71'
20. Texaco	2/03/87	OCS-G 1182	SM 11	17& 23 (36x36x36)	7187 Explosives	71'
21. ODECO	2/06/87	OCS-G 1983	SS 94	1 (48" caisson)	6187 Explosives	25'
22. ODECO	2/06/87	Ocs 0317	EI 47	9 (48" caisson)	5/87 Explosives	23'
23. ODECO	2/6/87	Ocs 064	SS 114	44 (48" caisson)	7187 Explosives	52'
24. Felmont	2/4/87	OCS-G 3258	WC 81	2 (96" caisson)	3/87 Explosives 7/31/87 Revised No Explosives	42'
25. Kerr-McGee	2/17/87	Ocs 0345	SS 29	9 (16.5,16.5)	5187 Explosives	15'
26. Samedan	2/19/87	OCS-G 3256	WC 67	B-1 (46" caisson)	3/87 Explosives	31'
27. Conoco	2/23/87	OCS-G 2820	WC 36	F (50x51)	5187 Explosives	30'
28. Conoco	2/23/87	Ocs 191	Wc 193	D (52x11O)	5187 Explosives	57'
29. Conoco	2/23/87	OCS-G 2880	SM 113	A (50x51)	5/87 Explosives	194'

(continued)

Table 1

Applications for Platform Removal

8/12/87

Company Name	Date Received & Approved	Lease No.	Area Block	Platform Name	Proposed Date for Removal & How	Water Depth
30. Conoco	2123/87	OCS-G 0978	EI 217	A (65x80)	5/87	109'
31. Conoco	2.123187	OCS-G 1983	Ss 94	A (65x80)	5187 Explosives	26'
32. Chevron	2126187 7/27187	OCS 0814	SS 108	18 (96 caisson)	6187 Explosives and Cutting Torch	25'
33. Chevron	2126187 7127187	OCS 0814	SS 108	24 (96" caisson)	6187 Explosives and Cutting Torch	25'
34. Chevron	2126187 7127187	OCS 0814	SS 108	29 (96 caisson)	6187 Explosives and Cutting Torch	25'
35. Chevron	2126187 7127187	OCS 0814	SS 108	33 (96" caisson)	6/87 Explosives and Cutting Torch	25'
36. Chevron	2/26/87 7127/81	OCS 0814	SS 108	38 (96 caisson)	6/87 Explosives and Cutting Torch	25'
37. Chevron	3/11187 5/15/87	OCS 0814	SS 108	S-93 Production Barge (92x112)	5187 Re-Float Barge	31'
38. Chevron	3/11/87 5/15/87	OCS 0814	SS 108	s-93 Mooring Dolphins and Flarepile	5187 Revised 4129187 No Explosives	31'
39. Chevron	3/13187	OCS 0498	ST 128	A (40x148)	7187 Explosives and Cutting Torch	104'
40. Chevron	3/30/87 7/24187	OCS-G 1302	MP 107	A (60x70)	6187 Explosives	52'
41. Exxon	3/30/87	Ocs 019	ST 54	A (120X100) A Quarters (30x50)	6187 Explosives	
42. Exxon	3/30/87	OCS-G 3065	MU A-90	A (70x171)	7187 Explosives	189'

(continued)

Table 1

Applications for Platform Removal

8/12/87

Company Name	Date Received & Approved	Lease No.	Area Block	Platform Name	Proposed Date for Removal & How	Water Depth
43. Unocal	4/03/87	OCS-G 1299	MP 100	5 (96 caisson)	6187 Explosives	30’
44. Chevron	4,/03/87 7/27187	OCS-G 1299	MP 100	5 (96 caisson)	6/87 Explosives & Cutting Torch	52’
45. Chevron	4/03/87 7/27/87	OCS-G 1301	MP 106	1 (96 caisson)	6/87 Explosives & Cutting Torch	49 ‘
46. Chevron	***4/03/87*** 7/27,87	OCS-G 1302	MP 107	1 (96 caisson)	6187 Explosives & Cutting Torch	57’
47. Chevron	4/03/87 7/27/87	OCS-G 1302	MP 107	4 (96 caisson)	6/87 Explosives & Cutting Torch	57’
48. Chevron	4/03/87 7127187	OCS-G 1302	MP 107	6 (96 caisson)	6/87 Explosives & Cutting Torch	57’
49. Chevron	4/03/87 7127/’,87	OCS-G 1305	MP 112	1 (144" caisson)	6/87 Explosives & Cutting Torch	65’
50. Chevron	4/03/87 7/27187	OCS-G 1305	MP 112	5 (96" caisson)	6/87 Explosives & Cutting Torch	58’
51. Chevron	4/03/87 7/27/87	OCS-G 1305	MP 112	6 (96" caisson)	6/87 Explosives & Cutting Torch	65’
52. Chevron	4/06/76	OCS-G 4561	BA A-42	A	6187 Explosives	136’
53. Chevron	6/06/87	OCS-G 4560	BA A-40	A	6187 Explosives	140’
S4. Apache	4/27/87	OCS-G 2610	EI 321	A (95x95)	10/87 Explosives	240 ‘
55. Chevron	4/22/87	OCS-G 118(I	SM 9	1 (12 caisson)	6187 Explosives & Cutting Torch	62’
56. Chevron	4/22/87	OCS-G 1180	SM 9	5 (96 caisson)	6/87 Explosives & Cutting Torch	63’
57, Chevron	4/22/87	OCS-G 4s58	EI 42	1 (26 conductor)	6/87 Explosives	13’

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Applications for Platform Removal

8/12/87

Company Name	Date Received & Approved	Lease No.	Area Block	Platform Name	Proposed Date for Removal & How	Water Depth
58. Mobil	4[27/87	Ocs 050	EI 120	Oil Storage Platform (100x50)	5/87 Explosives	37’
59. Chevron	5/04/87 6129187	Ocs 263	ST 21	7/7D Triangular Platform	8/87 Explosives Revised No. Expl.	34’
60. Chevron	5/04/87 6/29187	Ocs 263	ST 21	30/30D Triangular Platform	8/87 Explosives Revised No. Expl.	35’
61. CNG	5107/87	OCS-G 3802	WC 318	A (40x40)	6/87 Explosives	65’
62. Chevron	5/11/87	OCS-G 5660	GI 86	Penrod Rig No. 61	6/87 Explosives	246 ‘
63. Kerr-McGee	5/12/87	OCS-G 3245	HI 508	A [60x55)	7187 Explosives	184’
64. Amoco	5115187	OCS-G 1042	SS 292	A (72x103)	9187 Explosives	234’
65. Anadarko	5/2.5/87	OCS-G 4470 6/05/87	PL 2	A (80x75)	6187 Mechanical Method	30’
66. Mobil	6/05/87	Ocs 0245	WC 72	P-1 (30 caisson)	7187 Explosives	640 ‘
67. Mobil	6/05/87	Ocs 0245	WC 72	G-1 (30 caisson)	7/87 Explosives	30’
68. Mobil	6/05/87	Ocs 0246	WC 101	K-1 (30 caisson)	7/87 Explosives	40’
69. Mobil	6/05/87	OCS 0247	Wc 102	#18 (30” caisson)	7/87 Explosives	40’
70. Walter	6126187	OCS-G 3956	SA 7	A (20%20)	7187 Explosives	37’
71. CNG	7/09/87	OCS-G 1974	EC 118	#3	9187 Cryogenic Fracturing	65’
72. CNG	7109187	OCS-G 1974	EC 118	#4	9/87 Cryogenic *Fracturing*	65’
73. CNG	7109187	OCS-G 1974	EC 118	#A5	*9/87 Cryogenic* Fracturing	65’
74. Mobil	7109187	*OCS 0245*	Wc 72	#8 (30 caisson)	10/87 Explosives	39’
75. Texaco	7/09187	*OCS-G 5038*	EI 29	#2	8/87 Mechanically cut	17’

Table 2

Venture Economics

Year One Expenses

Operator Bond	$ 50,000
Salvage Annuity	50,000
Renovate Quarters	50,000
Paint Structure	50,000
Fence Production Equipment	20,000
Scuba Ramp to water	10,000
Elevator	20,000
Advertising	40,000
Rigs to Reef Pursuit	21,500
Political/Financial Advice	21,500
Project Management	54,000
Helicopter Transportation	510,000
Baseline Structural Survey	18,750
Catering Expenses	104,400
Insurance Coverage	161,200
Boat Transportation	150,000
Staff (Manager & Hand)	50,000
Legal Fees	25,000
Total Expenses	$1,406,350

Year One Income

Gas Production (net after operator expenses)	$ 120,000
Scuba/fishing	562,500
Food/bedding	180,000
Venture Participation Contribution	421,750
Major Contribution	250.000
Total Income	$1,543,250

Table 3

Following Year% Venture Economics

Expenses

Salvage Annuity	$ 50,000
Expand Quarters (and continuing maintenance)	100,000
Project Management	50,000
Helicopter Transportation	730,000
Catering	210,000
Insurance	90,000
Boat Transportation	200,000
Staff	100,000
Total Expenses	$1,530,000

Income

Gas Production (net after operator expenses)	$ 120,000
Scuba/fishing	1,124,000
Food/bedding	360,000
Rentals	60,000
Total Income	$1,664,000

Rigs-to-Reefs in the North Sea

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Introduction

At present there are some 150 fried offshore installations on the United Kingdom (UK) Continental Shelf. About two-thirds are in water less than 131.2 ft (40 m) deep in the southern North Sea and are of light weight, often around 330.6 short tons (300 metric tons). Much larger structures operate in the deep water of the central and northern North Sea. Steel platforms in 607.0 ft (185 m) of water sometimes weigh over 93,670 short tons (85,000 metric tons); and concrete gravity platforms can reach up to 716,300 short tons (650,000 metric tons). In 1987, some fields are approaching the end of their useful lives, and the question of platform decommissioning is being actively discussed. Relevant experience exists particularly from the Gulf of Mexico hut relates mostly to small structures in shallow water near the shore, and a very different set of problems must be faced wit', the larger North Sea platforms. The first of these will be due for decommissioning during the period 1991-1995, and about 60 in the following decade.

Platform Decommissioning

Looking first at international law, the 1958 Geneva Convention on the Continental Shelf provides that exploitation of natural resources must not result in any unjustifiable interference with navigation, fishing, or the conservation of living resources, and requires that any installations that are abandoned and disused must be entirely removed. The 1982 Convention on the Law of the Sea also reflects the principle of no unjustifiable interference with other users of the sea, but spells out in more detail the obligations of user states with regard to the removal of platforms and appears to imply that in some cases less than total removal is envisaged. The UK government attitude is that abandoned installations need be removed only totheextent required to take proper account of the legitimate interests of other users of the sea.

A working group of the International Maritime Organization has been preparing guidelines and standards for the removal of offshore installations and proposes that installations should be removed except where nonremoval or partial removal is consistent with the guidelines. These recommend case-by-case evaluations in which safety of navigation, rate and effect of structural deterioration, benefit to living resources, costs, feasibility and risks of removal, and the possibility of new uses should be taken into consideration. Among the standards, it is proposed that when living resources can be enhanced by leaving structures wholly or partly in place, the appropriate coastal state may so decide, and if such enhancement may be achieved by the placement on the seabed of material from removed structures (e.g., to create artificial reefs) then such material should be placed well away from traffic lanes andshould be adequately monitored. In addition to international legislation, UK domestic legislation provides that the site of an abandoned or disused structure shall be cleared "to the satisfaction of the Secretary of State."

It may be concluded that the coastal state may make the final decision on whether and how to remove an installation but must observe a number of constraints. Since on the UK Continental Shelf alone the complete removal of platforms is estimated to cost around $10.2 billion ($%,()()0 million) at 1984 prices, *a careful* examination of the options is clearly important.

The Options

Assuming that a platform *is no longer re-*quired for its original function, there are several relevant options. It may be utilized in situ for some new function such as for marine scientific research, as a center for search and rescue capabilities, *or* as *a com-*munications facility. Among more novel possibilities are the use of platforms for seabed disposal of hazardous wastes or as part of an integrated vessel traffic management scheme. None of these options has been evaluated further because it is unlikely that any non-oil-related use could be sufficiently profitable or essential to warrant the expense of continuing platform maintenance in situ. Alternatively, the platform may be toppled to provide navigation clearance and then left to deteriorate on the seabed. Although this is a cheap option, it may well be unattractive to operators because of continuing *legal* liability. Partial removal is also cheaper and would involve removal of topsides and the upper part of jackets. Removal material might be put on the seabed alongside the residual 98.4- 131.2 ft (30-40 m) *high* "stub," or it might be transported to land. The final option is to remove the structure completely, either dumping it in deep water, probably off the edge of the continental shelf, or taking it ashore, when parts of it might be salvaged and reused *or* sold as scrap.

It now seems likely that all the small platforms in the southern sector of the North Sea will be removed completely. If the 40-odd large *steel* structures in the central and northern sector are partially or completely removed as well, the UK will be disposing of a considerable quantity of durable, high-grade steel, much of it already fabricated into open lattice-work components similar to the steel artificial reefs currently being constructed by the Japanese. It is therefore suggested that we have an opportunity well suited to a UK reef-building program.

Artificial Reefs in the North Sea

The *Fishery Potential of Functional Platforms*

In the Gulf of Mexico the benefits to fisheries from operational platforms are fully recognized. A growing body of data confirms that installations in the North Sea also attract fish. Norwegian studies have shown that the density of certain fish species was up to ten times greater close to platforms than in areas more than 1,640.5 ft (500 m) away. In addition, a study initiated by the UK Offshore Operators Association and conducted by Abderdeen University Marine Studies Ltd. has involved the analysis of fish activity seen on videotapes from subsea structural inspections. It is clear that fish are associated with all the structures so far examined in the North *Sea.* Twenty species have been identified; tbe most common being saithe (*Pollachius virens*), cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), ling (Molva molva), pollack (*Pollachius pollachius*), *Norway* pout (*Trisopterus esmarkii*), 1 ong rough dab (*Hippoglossoides platessoides*), Norway haddock (*Sabestes viviparus*), and w ol f f is h (*Annarchichas lupus).* It is believed that these shoals (fish schools) spend at least some time in the vicinity of platforms and that the prime attraction is the reference point that the structure provides. Shoals appear to be orientated around or within a structure and may move around it in response to the underwater vehicle filming them, but they have never deserted the structure when disturbed.

In an attempt to determine if the operational artifacts of platforms were responsible for fish attraction rather than the mere physical presence of an open structure, a second survey was conducted on a completely submerged nonoperational oil installation in about 328.1 ft (100 m) in the central North Sea. Enhanced fish life was also observed there, with the same general pattern of saithe shoals near the top and a greater diversity at the seabed.

It is clear from these observations that the North Sea platforms do attract fish just as they do in the Gulf of Mexico, but it is important to note that the pattern of fishing activity and interests in the North Sea is very different from that in the Gulf. Given the environmental conditions in the North Sea, there is not the same tradition of recreational fishing offshore, and even if that did exist, most of the platforms are too far from the coast and in too turbulent waters for them to offer attractive prospects in this context. Also, since the pattern of fishery in the North Sea is almost entirely commercial, the North Sea fishermen do not see the oil installations as of any help. On the contrary, they regard the oil industry with concern. Floating and seabed debris damage their vessels and gear, losing them valuable fishing time, while the pipelines and platforms exclude them from fishing grounds. The fishermen of the North Sea understood that, when the oil eventually ran out, all the installations would be removed and the grounds would be returned to their original condition. Even if the North Sea platforms had proved to have fishery potential, it should be noted that the oil operators in the North Sea make use of the provision in the 1958 Geneva Convention that empowers states to create 1,641-ft (500-m) exclusion zones (safety zones) around fixed structures. Indeed, even fishing by platform personnel in their off-duty hours is often discouraged in order to protect divers and others working from the structure. In general, then, the prospects for fisheries around North Sea functional platforms are not attractive.

The Use of Abandoned Platforms in situ

The situation would be different after a platform had been abandoned, if only because the statutory safety zone would presumably no longer apply, and fishing operations could be conducted as close to the structure as the fishermen themselves deemed to be safe. A small wreck fishery is carried on around the UK coast, so relevant practice and techniques are not alien to our fishermen. To leave an intact platform *in situ* is not a viable option, however, since the required maintenance would be prohibitively expensive.

The lowest cost option would seem to be either toppling the structure where it stands or removing the topside and leaving the stump. Fishermen are strongly opposed to either of these solutions. Two of their greatest concerns about oil developments have always been the loss of access and the impact of debris. The latter must be accepted as a significant worry, since even the most robust structure abandoned under water will eventually breakup and could constitute a source of trouble, possibly over a wide area, damaging gear and interfering with fishing operations well into the future. The question of loss of access, however, is probably less apposite. Calculating even on the basis of a 1,641-ft (500-m) “No Fishing” zone around abandoned or toppled structures, as at present exists around operating platforms, the total exclusion area associated with 40 platforms would represent only about ().()15 percent of the UK North Sea sector, and in general it is difficult to see it as a major problem. Quite apart from the concerns of the fishermen about platforms or parts of them left *in situ*, there is the question of the continued liability of the operator—a question that has not so far been adequately answered in the North Sea.

In attempting an assessment of the possible advantages of these various options to fishermen, we should note that the main effect would be to attract fish. The observations quoted earlier suggest that about 10,000 fish would be a reasonable holding for a large structure, so with some 40 platforms available, an associated fish population of about 400,000 could be expected. Yet it can be calculated that, taking only the three species cod, haddock, and saithe, the number of individuals over one year old in the North Sea would be of the order of 6 billion. Clearly, even if all the fish associated with the platform were "new" in the sense that they would not exist but for the presence of the platform, the enhancement of the stocks would still be insignificant. Two points may be added: first, that even for a small-scale wreck fishery this enhancement would not be attractive, since most of the platforms are too far from the fishing ports to make such an exercise profitable; and second, that a certain degree of contamination will have built up around the base of most oil platforms, and while the sediments will eventually recover, the situation would not be encouraging for the establishment of demersal fishing close to the installation as soon as oil operations ceased. The conclusion is that most platforms left at their original site far offshore would have little to offer as artificial reefs.

Reefs Constricted from Parts of Platforms

The remaining option is the redeployment of parts of platforms at new sites as artificial reefs, and a large number of matters would need to be considered before such artificial reefs become operational. On the legal side, the Secretary of State bas wide powers to control fishing in coastal waters, so at the National level a mechanism is probably in place to produce any regulations required. Local agreements would also be needed to ensure the proper management and operation of the facility, and questions of ownership, legal liability, and navigation would have to be addressed. It is worth noting that although the exercise would be aimed at exploiting fish, the fishing industry may be far from unanimous in supporting it. The offshore section of the industry will not be particularly enthusiastic to see interest directed to coastal areas, and even among the inshore men, the fixed-gear sector would need to come to terms with the claims of the netsmen.

Given that such administrative and management issues can be harmoniously settled, there are still many questions about the layout and effectiveness of the reef. Would the material available be free of contamination so as to ensure taint-free fish? Would it remain intact long enough to be worthwhile without causing debris problems to other fishermen? Would the reef generate its own resident fish populations or would it simply act as an aggregator? What rate of fish take would be appropriate? What gear should be used? In countries like Japan questions of this type have been asked and satisfactorily answered. In the different conditions of the North Sea we need to return to those questions and, with this in view, the possibilities of a pilot reef are currently being discussed that would be designed to answer them. This project is known as SPARE (Scottish Pilot Artificial Reef Experiment) and it aims to establish and quantify the contributions that artificial reefs could make in Scottish waters of the North Sea by attracting fish to an inshore site and regenerating fish stocks and viable fisheries at such sites. It will also demonstrate the reef technology that is required in these inshore waters and will clarify the extent to which platform-related components make suitable reef modules. An acceptable site has been identified within three miles of the coast; a selection of appropriate reef components has been made, and the overall design of the reef has been agreed. The decision about materials and design were based on our experience and observations of fish behavior around operational North Sea platforms. Negotiations are well advanced towards the financing of the project. With the existing pressure on commercial fish stocks on the Continental Shelf of western Europe, there seems little doubt that a new approach of this sort, which offers distinct promise, ought to be adequately investigated.

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Artificial Reef Observations from a Manned Submersible Off Southeast Florida

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Abstract

Examination of 16 artificial reef structures with a two-person submersible in depths ranging from 98.4 -393.7 ft (30 to 120 m) indicated that the highest numbers of fish are found around reefs in water shallower than 150 ft (46 m). Fewer fish, especially those with tropical coral reef affinities, below 150 ft was probably caused by a thermocline, observed on all dives deeper than 140 ft (43 m). During 4 days in September 1987, temperatures from the surface down to approximately 140 ft were 86°-88°F (30°-31° C). whereas below 140 ft the temperature dropped as low as 51°F (10.6°C) at 390 ft (120 m). Algae and reef community encrusters (gorgonians, bryozoans, branching sponges, and corals), abundant on shallower structures, were absent below 150 ft.

Structures that penetrated above the thermocline, such as two upright oil "rigs" and a hopper barge, were also effective reefs. The open structure and high profile of the rigs enhance their use as artificial reefs by providing a range of well-aerated habitats. Any effect of substrate or postdeployment age on fish abundance could not be documented. Wood appeared to be a more effective fish-concentrating material but has a shorter useful life than does steel. The greatest diversity and numbers of fish were observed at the Miami sewer outfall.

Introduction

Numerous derelict ships and other material have been placed off southeast Florida for the purpose of enhancing fish stocks and sportsfishing. These artificial reefs, in water depths ranging from 98.4 to 393.7ft (30 to 120 m), provide an excellent opportunity to observe the relative effects of depth, temperature, substrate, and postdeployment age on local fish populations. Knowledge gained from study of selected reefs from a range of depths and on different substrates could provide information useful for management and future placement of artificial fishing reefs. In addition, the effectiveness of various kinds of materials and structure shapes could be assessed in such a study.

A research submersible capable of diving to 1,312 ft (400 m) was used to examine reefs as deep as 393.7 ft (120 m). For this short (September 7-10) study, we developed a "quick and dirty" assessment technique (video profiling) that allowed the examination and comparison of 16 separate reefs and a sewer outfall (figure 1). The study does not employ statistical manipulations, nor does it attempt to determine species composition and species-depth relationships. Population density and composition around various structures were estimated from video records made during submersible dives. Visual observations and impressions apart from the video data, however, are considered equally useful for the purposes of this study.

The structures examined included portions of five obsolete offshore oil production platforms (known locally as the Tenneco rigs), 10 ships, a barge, discarded service station storage tanks, and a sewer outfall. Two of the ten ships were composed of wood. The remaining structures, except for the sewer outfall, were composed of steel. Tbe sewer outfall consists of an elongate mound of rock rubble covering a large trunkline that feeds four vertical effluent outlets approximately 3.3 ft (1 m) in diameter and extending 11.8 inches (30 cm) above the main trunkline. Although one does not ordinarily consider sewer outfalls as artificial reefs, this one was included because it concentrates both fish and fishermen.

The words "concentrate" and "congregate" are used to describe accumulations of fish, whether the fish are drawn in from a broad area or are spawned directly at the reef site. Separating attracted fish from locally spawned fish is a difficult research problem not treated in this study.

Methods

The evaluation method consisted of identical, continuous video transects conducted at all sites. The "video sweeps" were made with a hand-held 8-mm video camera inside an underwater housing equipped with a wide-angle lens and positioned against the starboard porthole. Two kinds of video sweeps were conducted, always in a clockwise direction. The first base sweep was along the bottom with the contact between ship and substrate approximately in the center of view. The ship's hull forms the backdrop; thus, all fish seen were between the submersible and ship. The second deck sweep was around the deck with the top of the deck approximately in the center of view. The submersible was kept about 26.3 ft (8 m) from each target structure during sweeps, but because of debris and dangling lines, uniformity of distance was not always maintained. Deckline sweeps were especially difficult because the deck on most cargo ships seldom falls on a common horizontal plane. Some ships, such as the *Star Trek* or the hopper barge, were lying on their sides; thus, a true deckline sweep could not be made. Instead, the most horizontal side of the ship or barge was treated as the deck. Many of the fish were beyond the deckline; thus, observations are nonuniform because an unknown sample volume is involved. The clearer the water, the greater the number of fish that might be counted. The species found in open water above and beyond the deckline were often different than those around the baseline. Underwater photographs of selected sites are shown in figores 2-4.

Base sweeps of the Tenneco rigs presented a problem because the rigs touch bottom only at tbe four main corner pipes. Deck sweeps were easy to accomplish because the three structures had horizontal decks with railings. Other parts of the structures were also examined after the standard video sweeps were completed. Many more fish were seen than appeared in the video sweeps.

Fish identification and counting from video images are not a precise method. Some fish tended to track the submarine and remained continuously in view. Such fish were usually obvious and were not counted more than once. In the case of large schools, many fish were hidden behind others and could not be counted. Such encounters were simply called "schools" of fish. Schools that consisted of very small, unidentified fish were called "bait fish." Although not precise, the sweeps nevertheless were thought to provide a relative but crude measure of standing stock. Basic data, including depth, temperature, postdeployment age, material, substrate, and length of ship, as well as video fish counts, are given in table 1. Appendix A provides other observations regarding kinds of fish seen.

Submersible operations were conducted during calm, hot summer days from the 164.1 ft (50-m) R/V Powell. The S/V *Delta*, a 14.1 ft (4.3 -m)-long submersible certified to a diving depth of 1,312 ft (400 m), was deployed over the side with a hydraulic crane. The submarine is streamlined, with few protruding gadgets to become entangled in cables, nets, and other debris. Fortunately, most loose lines and cables had been stripped before the vessels were sunk, and there were no trawl nets. Lost fishing lines presented the greatest obstacles. Structures were remarkably easy to locate thanks to publicly available information provided by the Dade County Department of Environmental Resource Management. Artificial reef sites were located either by use of Loran C time differences (TD's) or by visual lineups between various buildings, water towers, and smokestacks on shore. A buoy was deployed once tbe structures were seen on the fathometer. The submersible simply followed the buoy line to the bottom, where the pilot either searched visually or used an onboard sonar. Most sites were sighted visually as soon as the submersible reached bottom. Visibility was never less than 75.5 ft (23 m) and was often greater than 98.4 ft (30 m). Because of time limitation, sites were chosen so as to evaluate a variety of structures, water depths, bottom types, construction materials, and postdeployment ages without wasting time during transit. There were many sites not visited because of time constraints,

Results and Discussion

In spite of variability inherent in our census technique, the counts, supplemented by other visual impressions, clearly showed that the most fish were on reefs in less than 147.7 ft (45 m) of water (table 1). The exceptions were the two deep Tenneco rigs that penetrate above the thermocline from approximately 196.9 ft (60 m) to 141.1 ft (43 m) and the hopper barge, which rests in its side and spans the column from 164.1 ft (50 m) to approximately 128.0 ft (39 m). Wrecks on rocky substrate appeared, in general, the most effective fish concentrators, but invariably they were in water shallower than 147.7 ft (45 m).

A thermocline was consistently encountered between 141.1 and 150.9 ft(43and46 m). From the surface down to approximately 141.1 ft (43 m), water temperature hovered around 86°F(300C), whereas below 150.9 ft (46 m) the temperature was around 66°F (19°C). At393.7ft (120 m)on the liberty ship, water temperature was as low as 51°F (10.6°C). Temperatures above the thermocline are probably lower during winter months. Temperature regime along the western margin of the Florida Straits is highly variable (Walforal and Wicklund, 1968). Temperature below the thermocline can be as cold in September as in February, and depth to the thermocline can change due to horizontal wave-like meanders and eddy shedding of the northward-flowing Florida Current (Lee, 1975; Lee and Mayer, 1977; Lee and Mooers, 1977). We believe the combination of depth (light penetration)and low temperature below the thermocline had a greater effect on fish populations than did the substrate, because below 150.9 ft (46 m), small bait fish and marine tropicals, when present, appeared to be torpid, and thick algal encrustations, encrusting corals, sponges, gorgonians, and bryozoans, abundant on shallower wrecks, were absent,

Theliberty ship (table 1 and appendix A), sunk in 393.7 ft (120 m) of water (figure 1), provided an example of extreme conditions. This was the only wreck where schools of amberjack (*Seriola dumerili*) were absent. The most abundant fish were flounders (Bothidae) lying on the muddy sand surrounding the ship. There were no algal encrustations, only pelecypod molluscs.

Two other ships, the *Sir Scott* in 219.8 ft (67 m) of water and the *Pioneer*, surrounded by discarded service station tanks in 216.6 ft (66 m) of water, were also relatively ineffective concentrators of fish. Amberjacks were present on both wrecks, however, and some large Warsaw groupers (*Epinephelus nigritus*) were seen (appendix A). The tanks surrounding the *Pioneer* were totally devoid of fish.

On the other hand, shallow wrecks, in depths of less than 150.9 ft (46 m), such as *Blue Fire, Ultra Freeze,* and the *Narwal*, harbored huge schools of grunt, jacks (Carangidae), yellowtail snapper (*Ocyurus chrysurus*), hogfish (*Lachnolaimus maximus*), mutton snapper (*Lutjanus analis*), and various species of parrotfish (Scaridae). These ships were heavily encrusted with sponges, gorgonians, small corals, bryozoa, and abundant fleshy algae. Numerous fish bites were visible where fish had bitten algae from the underlying white-painted surfaces. These bite marks indicate that some primary feeders (i.e., herbivorous fish) were receiving direct sustenance from algae, which would not be present in deeper water.

Two structures were composed of wood, an unnamed mine sweeper and the small trawler, *Moby One*. Even though the mine sweeper was in 196.9 ft (60 m) of water, it nevertheless harbored large numbers of fish. Both ships were badly deteriorated, especially the mine sweeper, which had been immersed 195 months. Deterioration of wood produces numerous nooks and crannies, and the resulting debris is organic and consumable. Numerous wood-boring organisms, eaten by many fish, also infest the decaying wood. In places the mine sweeper appeared to be held together by intertwined calcareous tubes of the wood-boring worm *Toredo* sp. Wood structures, because of the additional space and food they provide during decay, may override effects of depth and low temperature. The *Moby One,* in 98.4 ft (30 m) of water and immersed only 50 months, was shrouded with schools of grunts (Haemulidae), gray snapper (*Lutjanus griseus*), and yellowtail snapper (*Ocyurus chrysurus*) too numerous to count. The youngest artificial reef examined (17 months) was the *Narwal*, yet it had greater concentrations of fish than many of the older, and especially the deeper, ships. There was no obvious meaningful correlation between time of immersion and number of fish detected in this study. Had there been reefs only a month or two old, there may well have been a detectable immersion time effect.

The two deep Tenneco rigs and the hopper barge can be put into a slightly different class of reef because they span both temperature and depth zones. Three of the five Tenneco rigs sit in an east-west line in approximately 98.4 ft (30 m) of water with their upper decks situated around 59.1 ft (18 m), well within scuba-diving depth. All three were visited by sport divers and spearfishermen during our dives. The center rig has a deck made of solid plate, whereas the other two have decks composed of steel grating. The grating was found to harbor numerous species of small marine tropicals. Seaman, Lindberg and Gilbert (1987) identified more than 45 species of typical reef-dwelling fish in and around the grating of these two platforms. There were noticeably fewer small tropicals on the platform with solid deck plating.

Although these rigs were shrouded with fish, tbe fish were for the most part quite small. We suspect that hook-and-line and spearfishing tend to keep the populations of large edible fish to a minimum. Note in table 1 that “normalized counts, ” given for shipwrecks, are not provided for the rigs.

The two deep rigs were considerably different than the shallow rigs. Because they rise from approximately 196.9 ft (60 m) to

141.1 ft (43-m) depths, scuba divers seldom dive there, and anglers find it difficult to anchor. Instead of resting on rocky bottom, as do the shallow rigs, these rest on rippled sand. Currents, minimal during our dive, range as high as 3 knots at this site. Large edible fish, such as Warsaw grouper, snowy grouper (*Epinephelus niveatus*), mutton and Cubrera snapper (*Lutjanus analis* and *L. cyanopterus*), were sighted on the bottom beneath both platforms. Around the top at 141.1 ft (43 m), there were barracuda (*Sphyraena* barracuda) and schooling amberjack and within the legs numerous angel (Chaetodontidae) and triggerfish (Balistidae). The upper surfaces near the top were coated with algae. Algae were absent near the bottom below the thermocline. The video sweeps show only what was present on the bottom and around the top; however, numerous fish make use of the entire vertical extent of the structure. Large vertical structures such as these make particularly attractive artificial reefs, as noted around oil rigs in the Gulf of Mexico (Shinn, 1974; Ditton and Auyong, 1984; Reggio, 1987).

The hopper barge was similar to the rigs because it lies on its port side and has a vertical relief of approximately 39.4 ft (12 m). The open hoppers allow unimpeded water circulation. Algae and other encrusters were abundant on the high starboard side but almost absent near the bottom at 164,1 ft (50 m). Fish were most abundant around the highest portion (appendix A).

The Miami sewer outfall proved to be one of the more interesting sites. Although it was impossible to make comparative video sweeps, the numbers and variety of fish observed were greater than at any other reef, including natural ones. Schooling fish included French grunts (*Haemulon flavolineatum*), pork fish (*Anisotremus virginicus*), spade fish (*Chaetodipterus faber*), amberjack (*Seriola dumerili*), horse-eye jack (*Caranx latus*), blue runners (*Caranx fusus*), barracuda (*Sphyraena barracuda)*, Bermuda chubs (*Kyphosus sectatrix*), yellowtail (*Ocyurus chrysurus*) and grey snapper (*Lutjanus griseus*), and an occasional mutton snapper (*L. analis*) and hogfish (*Lachnolaimus maximus*). Sting rays (*Dasyatis americana*) and cobia (*Rachycentron canadum*), not seen elsewhere, were also observed. Typical tropical reef fish roamed the surrounding sponge- and algae-coated rocks. Damsels (*Pomacentridae*), rock beauties (*Holocanthus tricolor)*, and both French (*Pomacanthus paru*) and queen angelfish (*Holocanthus ciliaris*) were common, to name a few.

Why fish should concentrate there is not understood. We attempted to observe feeding behavior, but no feeding could be detected. Fish never swam into the upwelling effluent. The brown translucent effluent (more than 90 percent of the solids are removed at the treatment plant) consists mainly of fresh water that rises vertically. Effluent does not mix with sea water until nearly reaching the surface. The bottom 49.2 ft (15 m) of the water column surrounding the outlets is clear, and visually the bottom looks like that typical of coral reefs, except for the rock rubble produced during digging of the trench that contains the main pipe. All the schooling fish appeared to be in an excited state, swimming rapidly back and forth. They may have been attracted by the sound of the rushing water, audible from inside the submersible, or by upwelling currents and turbulence created around the vertical effluent streams. The effluent creates a boil at the surface, 98.4 ft (30 m) above, and becomes entrained and diluted in the Gulf Stream current and carried northward. Fishermen avoid the boil (known as the “rose bowl”) and downwind areas (usually the north and west sides) but anchor and fish the southern margin. Thus, although there is fishing pressure, it is slightly to the south of the main fish concentrations. Divers never dive there.

Conclusions

1. Artificial reefs off south Florida have higher observed fish densities if placed in less than 147.7 ft (45 m) of water.

2. Temperature and depth are most important and probably override effects of substrate, although change from rock to sand closely coincides with the 147.7 ft (45-m) depth contour and the thermocline at the time of our observations.

3. Structures with high relief (such as oil rigs) are effective in water deeper than 147.7 ft (45 m), especially if they extend through the thermocline.

4. Wooden ships attract more fish than steel ships; however, they deteriorate more quickly.

5. Immersion time greater than 17 months has no noticeable effect on concentration efficiency.

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Appendix A

Tenneco

1. Barracuda, numerous bait fish and marine tropicals in deck grating. Hogfish near bottom. No schooling fish.

2. Numerous pelagic fish (amberjack, barracuda, bar jack [*Caranx tuber]*, blue runner [C. *fusus*]) and bait fish schools. Fewer tropicals than on Tenneco No. 1.

3. Schools of amberjack, barracks, barracuda, bait fish, numerous tropicals in deck grating.

4. Snowy grouper, Warsaw grouper, mutton and Cubrera snapper, and amberjacks present.

5. Snowy grouper, two large Warsaw groupers, and school of bait fish.

Narwal

Many schools of bait fish, bar jacks, and goat fish (*Mulloidichthys martinicus*). Saw one grouper.

Rossmerry

School of amberjack above wreck. Overall, few fish seen and no algae on hull.

Mine Sweeper

Large school of amberjack and bait fish above wreck, schools of bait fish within wooden skeleton, two large Warsaw groupers. Ship decayed almost beyond recognition and visible portion is much shorter than 196.9 ft (60 m) when first sunk. Average elevation off bottom is 4.9 ft (1.5 m). Most intact part is transom which stands approximately 8 ft (2.4 m) high.

Liberty

Morays (Muraenidae), flounder (Bothidae), and numerous crabs on mud bottom. Small, slow-swimming bait fish along deck line. No algae on hull but encrusted with oysterlike bivalves. No amberjack, but some small groupers present. Warsaw groupers not seen, and water visibility was greater than 108.3 ft (33 m).

Moby One

School fish (grunts and gray snappers) so numerous that counting was not possible. Amberjack and barracuda overhead.

Hopper Barge

Large school of amberjack, horse-eye jack, bar jack, gray snapper, barracuda, and abundant growth on highest part of hull

Ultra Freeze

Schools of amberjack and horse-eye jacks following submersible, several African pompano, two large jewfish (*Epinephelus itajara*) living in dynamited hole in port stern section (one approximately 150 lb (68 kg), the other approximately 200-250 lb [90.7 -113.4 kg]).

Star lick

One large 85-lb (38.6 kg) Warsaw grouper and amberjack school above wreck. Ship lying on starboard side. Large school of horse-eye jacks (in side hull), bait fish schools, pompano, snapper, and two smaller Warsaw groupers also present.

Sir Scott

One Warsaw grouper. No schools of bait fish, but a small school of amberjack is present.

Pioneer and Tanks

Four Warsaw groupers at stern on highest point of ship. Amberjacks, but no bait fish. Tanks scattered around site were devoid of fish. Ship is lying on starboard side.

Blue Fire

Large schools of grunts (uncountable) and bait fish and many grunts inside hull. Several hogfish and small black grouper (*Mycteroperca bonaci*) on bottom near ship. Schools of amberjack and horse-eye jacks, three barracuda, numerous small yellowtail snapper swimming above wreck. Fish generally abundant.

Sewer Outfall

At 100 ft (30.5 m) too dark for video. Abundant fish in vicinity of 4 vertical outlets 3.3 ft (1 m) in diameter. See text for list of species.

Mr. Eugene Shinn is project chief at the U.S. Geological Survey Fisher Island research station and adjunct professor at the University of Miami Rosentiel School of Marine and Atmospheric Sciences. Mr. Shinn is a native of Florida and a graduate of the University of Miami. With over 100 publications in scientific journals to his credit, Mr. Shinn's major research interest focuses on the geology of coral reefs resulting from extensive investigations in the Florida Keys and the Arabian Gulf, Prior to his 13-year tenure with the U.S. Geological Survey, Mr. Shinn was a contributor to the First International Artificial Reef Conference held in New Orleans in 1974.

Mr. Robert L Wicklund is director of tbe Caribbean Martime Research Center at Lee Stocking Island in the Exuma Islands, Bahamas, and adjunct professor at the Univeristy of South Carolina. He currently manages several mariculture projects, including studies of *Talapia*, grouper, and conch. Mr. Wicklund has played a key role in the NOAA National Undersea Research Program (NURP) and for many years served as site manager for the NOAA hydrolab project. Mr. Wicklund's primary interest are fishery conservation and enhancement of fisheries in undeveloped nations.

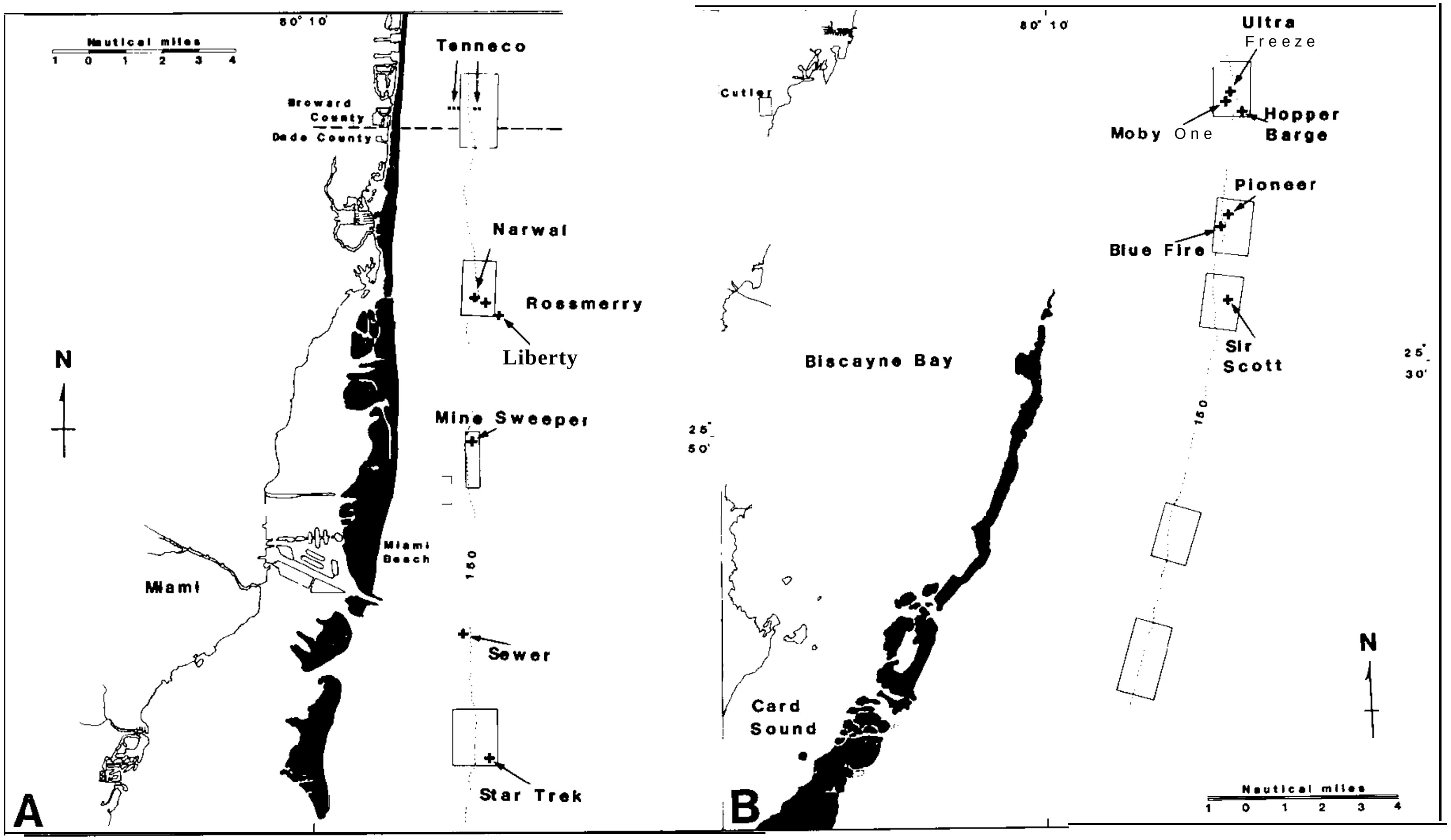
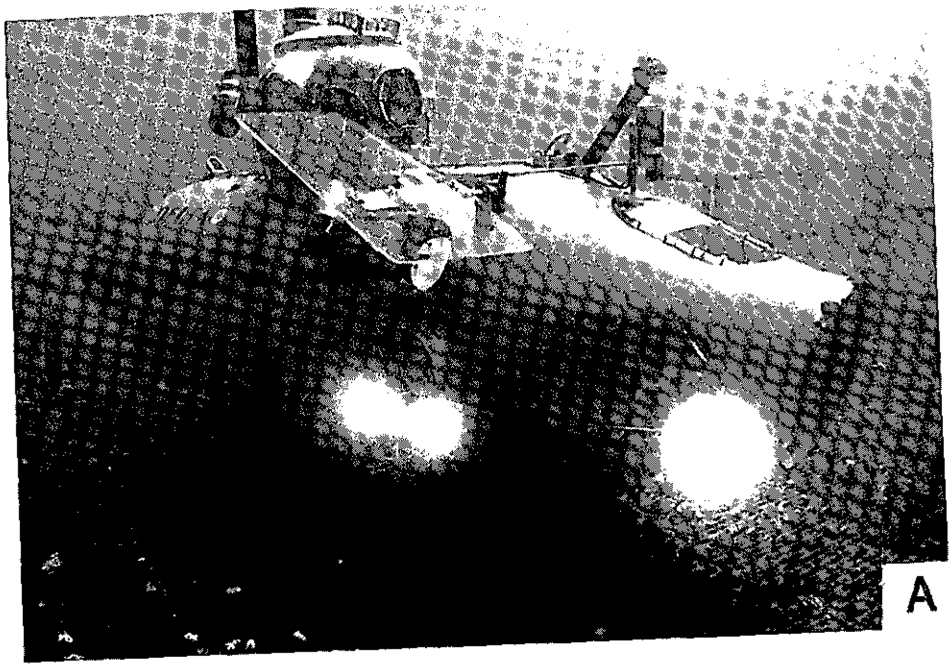
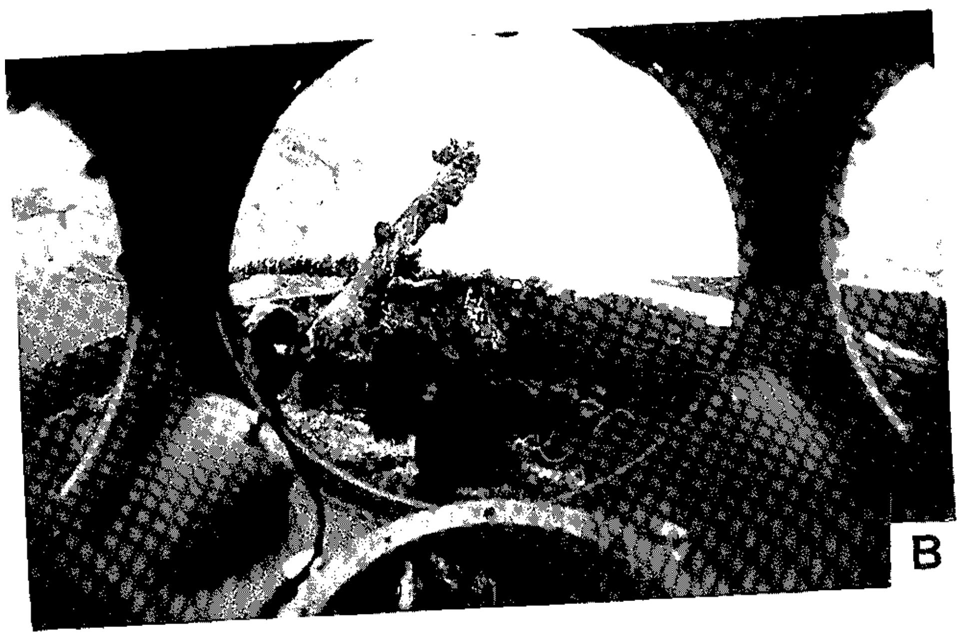


Figure 1. (A) Map of area off Miami and Key Biscayne (Dade County), Florida, showing designated artificial reef sites (rectangles) and names indicating locations of structures examined in this study. Map is modified from location map provided by Dade County. (B) South portion of study area (map connects directly with north portion shown in A). The 150.9-ft (46-m) contour is shown by a dotted line.

AS SUBMITTED BY AUTHOR



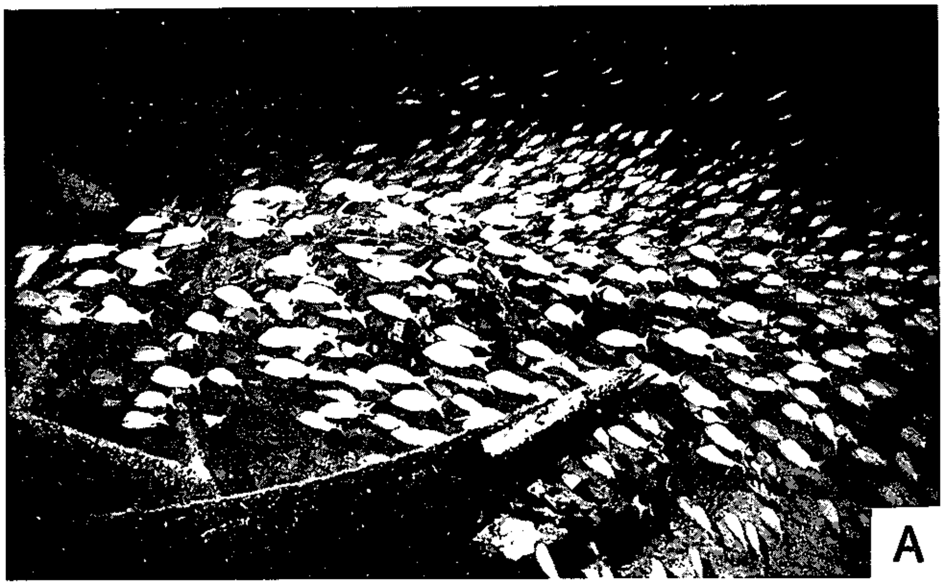
(A) Submersible Delta resting on open mesh deck of Tenneco rig. See figure 1 for location.



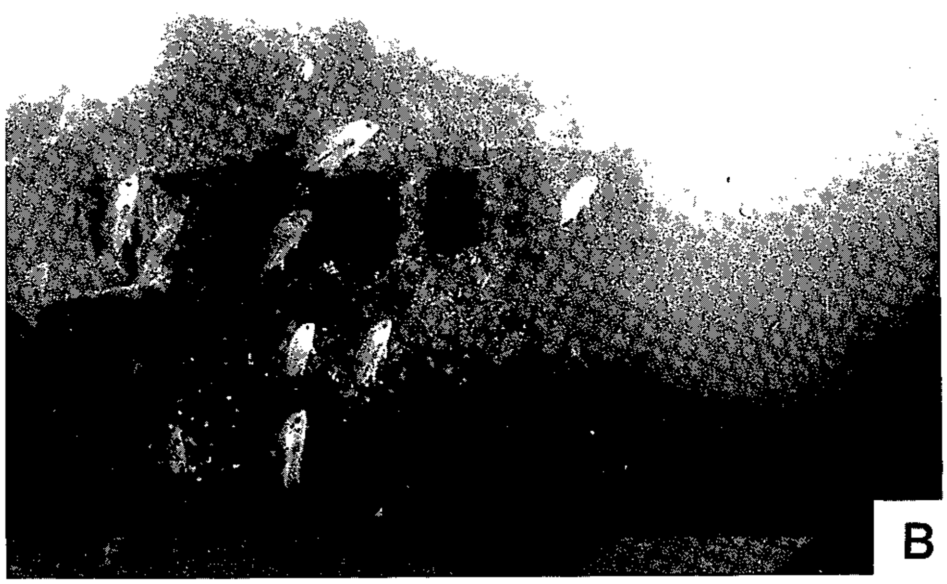
ιx lams)

(B) View through forward ports of submersible Delta showing school of horse-eye jacks (Caran: over deck of Ultra Freeze.

Figure 2.

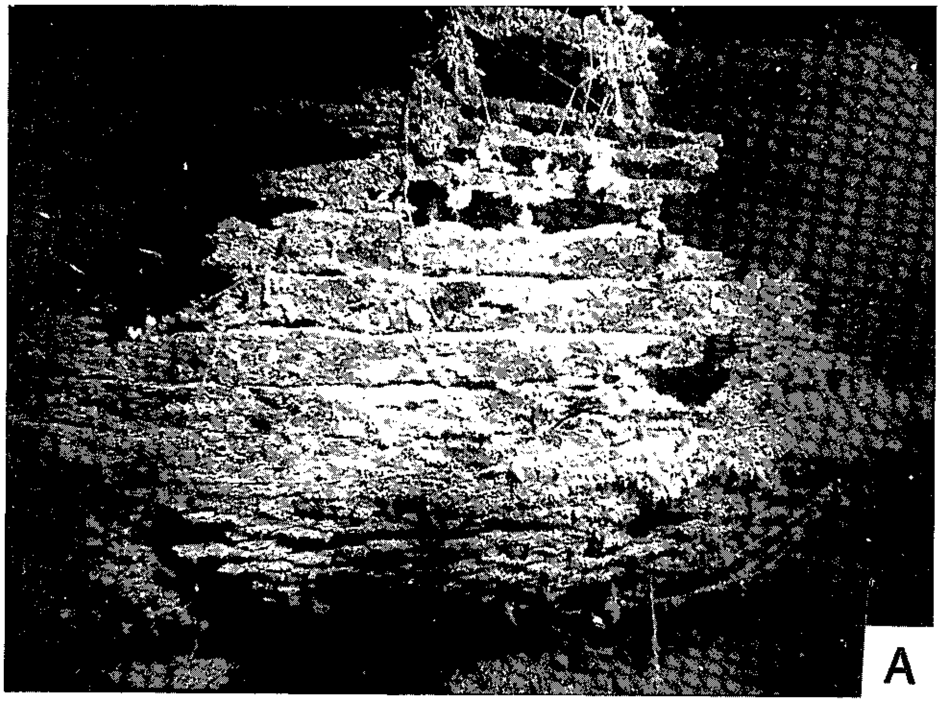


(A) School of grunts (Haemulidae) over the wooden ship Moby One.

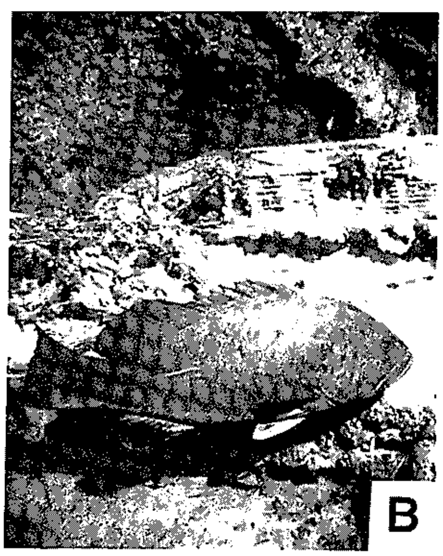


(B) Horse-eye jack (Caranx latus around wheelhouse of Ultra Freeze. Two large jew fish (Epinephelus itajaara) occupy hull below wheelhouse.

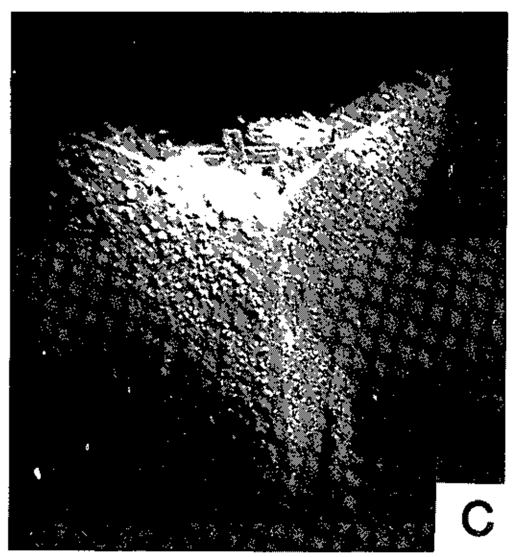
Figure 3



(A) Portion of the highly deteriorated wooden mine sweeper at depth of 190.3 ft. (58 m.). Note lost fishing lines.



(B) Large Warsaw grouper (Epinephelus nigritus) on mine sweeper.



(C) Bow of liberty ship (depth 393.7 ft; 120m). Note encrustation of oysterlike pelecypods and general lack of fish. Four small unidentified "bait fish can be seen *just* above bow.

Figure 4.

Table 1

Basic Data for All Sites Examined

(Under video pro files, fish counts for base and deck are given except where data were not available. To the right of the actual count, the column "Norm" is the normalized count or the actual count divided by the length of the sweep, which includes both sides of the ship [i.e., length of the ship x2]. See Appendix A for comments.)

Site	Depth to Bottom (ft)	Depth to Bottom (m)	Material	Age (me)	Bottom Temp (°C)	Length (ft)	Length (m)	Substrate	Video Profiles: Base Count	Video Profiles: Fish Norm	Video Profiles: Deck Count	Video Profiles: Fish Norm
Tenneco												
Rig 1	100	30	Steel	23	30	NA		Rock	8	-	35	-
Rig 2	100	30		23	30	NA		Rock			55	-
Rig 3	100	30		23	30	NA		Rock			115	-
Rig 4	200	60		23	30	NA		Sand	11		58	
Rig 5	200	60		23	30	NA		Sand	26		17	-
Sewer	100	30	NA		30	NA		Rock	see text		see text	
Moby 1	100	30	Wood	50	30	75	23	Rock	100	-	100	
Blue Fire	110	33	Steel	56	30	175	53	Rock	38	10,8	83	23.7
Narwal	115	35	Steel	17	30	137	42	Rock	91	33.2	55	20.0
Ultra Freeze	120	36	Steel	38	30	195	59	Rock	75	19.2	75	19.2
Hopper Barge	165	50	Steel	75	19	150	46	Sand	5	1.6	118	39.3
Mine Sweeper	190	58	Wood	195	19	177	54	Sand	54	15.0	109	30.7
Star Trek	210	64	Steel	62	19	200	61	Sand	9	2.2	12	3.0
Pioneer & Tanks	215	65	Steel	49	19	195	59	Sand	3	0.7	9	2.3
Sir Scott	220	67	Steel	31	19	267	81	Sand	14	2.6	22	4.1
Rossmerry	240	73	Steel	23	19	195	59	Sand	31	7.9	video fail	
Liberty	390	119	Steel	136	10.6	450	137	Mud	15	1,6		

Panel on National and International Possibilities and Concerns Related to Use of Petroleum Structures for Fisheries Enhancement

Mr. Dana Larson
The Rigs-to. **Reefs** Company
Houston, Texas

The world community is currently discussing various interpretations of the legal requirements for removing redundant petroleum structures as presently mandated under the 1958 Geneva Convention on the Continental Shelf and as proposed under the Law of the Sea Treaty. An estimated 6,000 petroleum structures have been erected off the coasts of 40 countries with an estimated removal cost of **$25** to $50 billion 1983 dollars. The United States has some 4,000 of these structures with estimated removal costs of $7.5 m $10 billion. These discussions are centered within the International Maritime Organization (IMO), which has the recognized world competence for setting standards for safety at sea and navigation.

Several of the agencies within the United States Government's delegation to the IMO deliberations were represented on the Panel. They included

- Captain Geoffrey R. Grieveldinger, Judge Advocate General's Corps, U.S. Navy, Department of Defense.
- Captain James Card, Chief of the Merchant Vessel Inspections and Documentation, U.S. Coast Guard, Department of Transportation.
- Gerald Rhodes, Chief, Rules, Orders, and Standards Branch, Minerals Management Service, Department of the Interior.
- William S. Griffin. Jr,. Manager of Capital Budget and Project Analysis for the Exploration and Production Group of Phillips Petroleum Company.

The panel moderator, William 1? Dubose, IV, Government Affairs Representative, National Ocean Industry Association, introduced the topic and speakers and encouraged audience discussion.

Captain Grieveldinger was the leadoff speaker and oriented the audience in regard to the complex background leading to the current discussions at the IMO Subcommittee on Safety of Navigation. The U.S. Navy has a great interest in national defense and surface and subsurface navigation.

Captain Card reported that the U.S. Coast Guard's involvement in the "Rigs-to-Reefs" effort is not limited to waters within the jurisdiction of the United States. The Coast Guard's responsibility to ensure the safety of navigation through the permit review process and its private aids to navigation program is important in carrying out the mandates set forth in the National Fishing Enhancement Act (NFEA) of 1984. However, as the agency acting as the official U.S. delegate to the IMO Subcommittee on Navigation, the Coast Guard also has the broader responsibility to present a position to that forum that will address the safety, economic, and environmental interests of the United States.

Jerry Rhodes' prepared statement emphasized the support of the Department of the Interior (DOI) for converting selected structures into artificial reefs as provided for under the NFEA. The DO1 is concerned about the proper plugging of wells, the method of platform removal, and the impact of explosives upon endangered species and marine mammals. The Section 7 consultations emphasize the fact that a platform constructed for oil and gas production creates an environment that biological communities quickly colonize. The recent toppling in place of a platform as a permitted reef in South Marsh Island Block 146 was recognized as being one of a few such instances that would occur in the Gulf.

Bill Griffin presented a slide show depicting the worldwide distribution of structures by geography and by water depth, the evolution of development of deepwater structures, and the economics of installation and removal. Most of his talk centered on the exceptionally large North Sea structures and their associated costs of removal. Only one structure has been removed from the North Sea and the costs were eight times greater than the installation costs of 13 years earlier.

After Panel members made introductory statements, Moderator Bill DuBose allowed some questions from the audience. Perhaps the most interesting questions centered on allocation quotas. Captain Grieveldinger responded that the current draft IMO paper proposed a maximum platform retention quota of two percent. Upon further questioning, he said the nations were currently discussing such issues as equitable means of allocating this two percent among countries, depths, purposes, economics, removal technologies, safety, etc.

Mr. Dana Larson is a retired Exxon employee who spent a large part of his career in environmental and regulatory affairs. In 1979 he was instrumental in the creation of the first preplanned oil and gas structure dedicated as an artificial reef off the west coast of Florida. Mr. Larson was responsible for the creation of the National Ocean Industry Association's Rigs-to-Reefs Committee and has served as its chairman since its inception more than eight years ago. In 19S4 the Secretary of the Interior recognized him as the "Father of Rigs-to-Reefs" in America. Mr. Larson has been an international R,gs-to-Reefs consultant and holds the title of Vice President in The Rigs-to-Reefs Company.

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and Mineral resources and works to assure that their development is in the bast interest of all our people, The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. Administration.