OCS Study
MMS 2001-039

Gulf of Mexico
Marine Protected Species Workshop

June 1999

U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

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BACKGROUND

INTRODUCTION

Dr. William Lang
Ms. Dagmar Fertl
Minerals Management Service

The Minerals Management Service (MMS) is a bureau within the U.S. Department of the Interior. It is responsible for ensuring that exploration and production of oil and gas reserves in Federal offshore waters, the Outer Continental Shelf (OCS), are conducted in a manner that balances orderly energy resource development with protection of the human, marine and coastal environments as mandated under the Outer Continental Shelf Lands Act (OCSLA). To help meet these OCSLA requirements and also comply with the National Environmental Policy Act (NEPA), the MMS conducts various environmental analyses. Part of this process includes sponsoring new research programs or studies to obtain needed data. A national OCS Environmental Studies Program was initiated in 1973 to provide environmental information and analyses of marine and coastal ecosystems within OCS planning areas (MMS 1990a).

The MMS often holds topic-specific workshops to review existing information and determine future study needs. This workshop represents the third protected species meeting for the Gulf of Mexico (GOM) (MMS 1983; 1990b). For this workshop, “Protected species” refers to those marine animals afforded protection under the Endangered Species Act (ESA) and Marine Mammal Protection Act (MMPA). The MMPA protects all marine mammals occurring in the GOM (twenty-eight cetacean species and the West Indian manatee). The ESA lists six large whale species and the manatee as endangered and five sea turtle species as threatened or endangered. The animals of concern are GOM marine mammal and sea turtle species listed in Table 1.

Since the MMS does not maintain research facilities, nearly all MMS studies represent contracts to external research groups or cooperative funding with state or federal agencies and industry. Though the MMS strives to support studies that provide quality data useful to the broader community, studies are not conducted for basic research purposes but to support programmatic needs.

Although the MMS “Studies Program” was created in 1973 (then under the Bureau of Land Management) to address information needs for the OCSLA and NEPA, in 1975, protected species studies were initiated to support MMPA and ESA information needs and have remained an important component of the studies program (MMS 1990a). Historically, protected species studies funded by MMS began with surveys of the distribution and abundance of animals that may be at risk in OCS planning areas as well as literature analyses, modeling and limited experimentation on effects of oil spills and acoustic disturbance on marine mammals (Geraci and St. Aubin 1990; Richardson *et al.* 1995). Early survey studies have evolved into multi-discipline analyses correlating physical and biological parameters to marine mammals distributions, such as SCOPEX in the Atlantic (Kenney & Wishner 1995) and Gulfcet II in the GOM (Davis *et al.* 2000).

Table 1. Marine Mammals and Sea Turtles of the Gulf of Mexico.

Marine Mammals

Order Cetacea

Suborder Mysticeti (baleen whales)
Family Balaenidae
Eubalaena glacialis, northern right whale *
Family Balaenopteridae
Balaenoptera musculus, blue whale *
Balaenoptera physalus, fin whale *
Balaenoptera borealis, sei whale *
Balaenoptera edeni, Bryde's whale
Balaenoptera acutorostrata, minke whale
Megaptera novaeangliae, humpback whale *
Suborder Odontoceti (toothed whales)
Family Physeteridae
Physeter macrocephalus, sperm whale *
Family Kogiidae
Kogia breviceps, pygmy sperm whale
Kogia simus, dwarf sperm whale
Family Ziphiidae
Mesoplodon bidens, Sowerby's beaked whale
Mesoplodon densirostris, Blainville's beaked whale
Mesoplodon europaeus, Gervais' beaked whale
Ziphius cavirostris, Cuvier's beaked whale

Order Cetacea (continued)

Family Delphinidae
Orcinus orca, killer whale
Pseudorca crassidens, false killer whale
Feresa attenuata, pygmy killer whale
Globicephala macrorhynchus, short-finned pilot whale
Grampus griseus, Risso's dolphin
Peponocephala electra, melon-headed whale
Tursiops truncatus, Atlantic bottlenose dolphin
Steno bredanensis, rough-toothed dolphin
Stenella coeruleoalba, striped dolphin
Stenella attenuata, pantropical spotted dolphin
Stenella clymene, Clymene dolphin
Stenella frontalis, Atlantic spotted dolphin
Stenella longirostris, spinner dolphin
Lagenodelphis hosei, Fraser's dolphin

Order Carnivora

Suborder Pinnipedia (seals, sea lions)
Family Otariidae
Zalophus californianus, California sea lion I
Family Phocidae
Monachus tropicalis, Caribbean monk seal Ex

Order Sirenia

Family Trichechidae
Trichechus manatus West Indian manatee *

Sea Turtles

Caretta caretta, loggerhead *
Lepidochelys kempi, Kemp's ridley *
Dermochelys coriacea, leatherback *
Chelonia mydas, green *
Eretmochelys imbricata, hawksbill *

I = introduced; Ex = extinct; * = endangered

In addition to environmental studies and the workshop forum to evaluate issues and obtain new information, MMS also funds research through the Technology, Assessment and Research Program (TAR). TAR works with engineering and technology issues, often in close cooperation with industry. For many effects issues, engineering analyses and technology assessment are essential components to fully understand environmental effects. For example, recent efforts to better evaluate effects of explosive removal of offshore structures on sea turtles and cetaceans has involved cooperative planning with TAR, the Environmental Studies Program, and industry through the Offshore Operators Committee.

As we begin this workshop, the types of possible effects of offshore petroleum activities on protected species have been identified with few, if any, changes in the list since the 1980s (Geraci and St. Aubin 1985). Dr. Robert Hofman of the Marine Mammal Commission listed these effects during the 1989 workshop (Table 2). While this list of topics remains valid for 1999, the amount of information for each topic has increased and perhaps, of most interest for this meeting, the perception of relative risks has evolved. For example, information on effects of oil exposure on marine mammals and means to clean and rehabilitate captured animals has substantially increased, in no small part, due to extensive studies and experience resulting from the 1989 *Exxon Valdez* spill (Loughlin 1994). Not that the concern or potential for impact has subsided, but the demand for additional oil effects studies is considerably less in 1999 relative to the 1983 or 1989 workshops.

Conversely, although MMS has studied acoustic disturbance issues for Alaska protected species from the onset of the studies program, the perception that potentially significant acoustic effects from a variety of human activities exist in the world oceans is a recent trend (Jasny 1999). Acoustic effects from offshore petroleum exploration was a recognized issue in the North Atlantic lease sale NEPA documents in the 1980s, but remained a relatively secondary concern. In contrast, seismic exploration is highlighted as a major concern during recent environmental assessments for proposed petroleum exploration on the Canadian Georges Bank (NRC/NSPD 1999).

Participants at the 1989 workshop reviewed the existing state of knowledge for GOM protected species and possible sources of impacts on them. The workshop was divided into invited presentations, discussion groups, summation session, and culminated in the development of study priorities. Marine mammal and sea turtle sessions were held separately. Recommendations from the workshop directly contributed to MMS planning and funding of the GulfCet I study and collaboration with the Biological Resources Division of the U.S. Geological Survey for award of GulfCet II. A synopsis of Kemp's ridley biological data from Dr. Rene Marquez (Marquez 1994) was also supported by MMS and funding for marine mammal observers aboard NMFS research vessels is an ongoing cooperative agreement.

This workshop was conducted differently from our two previous meetings. Since the 1989 workshop effectively defined basic issues and research needs, the emphasis at this meeting was to review accomplishments since 1989, what new factors should be considered, and what should MMS do next? The number of presentations was increased relative to past workshops and they address the range of topics integral to MMS programmatic planning. In addition to "biology" of protected species, offshore industry activities, new technology and exploration trends were presented as well as recent developments concerning the MMPA and ESA.

Table 2. Possible effects of offshore oil and gas development on marine mammals (compiled by Robert J. Hofman).

I. Disturbance/noise from ship and aircraft operations, seismic profiling, platform construction, drilling, etc., may
  a. interfere with or disrupt vocal communications, feeding, breeding or other vital functions;
  b. cause animals to avoid or abandon important feeding areas, breeding areas, resting areas, or migratory routes;
  c. cause animals to use marginal habitat or to concentrate in undisturbed areas, which in turn may result in crowding, overexploited food resources, increased mortality, and decreased reproduction;
  d. stress animals and make them more vulnerable to parasites, disease, and/or predation;
  e. attract animals, making them more vulnerable to oil spills, hunting, harassment; and
  f. alter the distribution, density, movements, or behavior of important prey species.

II. Dumping, dredging, drilling, and platform, pipeline, support facility, and storage facility construction may
  a. damage or destroy haul-out sites, feeding areas, or other areas of similar importance; and
  b. adversely affect the distribution, abundance, behavior, or productivity of important prey species.

III. Oil from well blowouts, pipeline breaks, tanker accidents, and chronic discharges associated with routine operations may
  a. kill or debilitate marine mammals by matting and reducing the insulating quality of fur; cause acute or chronic poisoning due to inhalation or ingestion of toxic hydrocarbon components or ingestion of contaminated food; cause irritation of skin, eyes, or mucous membrane, or fouling of baleen;
  b. kill, debilitate, or otherwise reduce the abundance or productivity of important prey species and/or species lower in the marine food web, resulting in acute or chronic nutritional deficiencies, including starvation;
  c. stress animals, making them more vulnerable to disease, parasitism, and/or predation;
  d. interfere with the formation of mother-pup bonds and cause mothers (particularly colonial breeding pinnipeds) to abandon pups;
  e. cause animals to abandon or avoid contaminated breeding areas, feeding areas, etc., and/or to concentrate in unaffected areas; and
  f. attract animals to debilitated prey, making them more vulnerable to contact with oil and the ingestion of contaminated prey.

IV. Contaminants in drilling muds, waste discharge, etc. may
  a. kill or debilitate animals that are exposed to the contaminants; and
  b. contaminate, accumulate in, and kill or debilitate important prey species or species lower in the marine food web.

V. Increased ship traffic may increase the probability of collisions between ships and marine mammals.

Rather than breakout groups, nine protected species experts were invited to participate in a workshop advisory panel. As detailed in the summary chapter, the panel received four questions (Table 3) from the MMS as topics to stimulate discussions. Following a panel discussion, there was an open floor discussion to allow for additional questions, feedback and perspectives from all workshop participants. After the workshop, MMS staff and other federal representative met with the expert panel for a post-workshop evaluation and an additional opportunity to discuss study planning.

Table 3. Questions for workshop advisory panel.

Suggested Questions for Discussion by Expert Panel

The purpose of the workshop is to identify the significant uncertainties and propose research and monitoring programs needed to resolve them.

In view of the sponsor of the workshop, the first priority is to address information needs most pertinent to MMS-regulated activities. The discussion will then be open for the panel to discuss other important items of concern.

1. Will a move into deeper water for exploration and production bring special considerations and concerns that have not yet been addressed by prior studies?

2. What special concerns will MMS need to address in the Eastern Planning Area and other shallow water areas in the Gulf?

3. The following are environmental assessment specific questions that the MMS has received. Can these concerns be addressed and what is the approach?

   A. MMS lease sale environmental impact statements were noted to have little information on the distribution patterns or abundance of the individual marine mammal species and populations that inhabit the northern Gulf or how they would likely be affected.

   B. Difficulties exist relative to indicating specific areas where seismic surveys, drilling, helicopter and vessel support activities, etc., might overlap with important feeding, breeding, calving, nursing, or migratory areas.

   C. What type of research or monitoring programs are needed to address points A and B?

4. What should MMS's role in understanding, and conservation, of protected species be in relation to other government/funding agencies and research groups?

Although there are multiple purposes for sponsoring this type of workshop, the key factor for MMS is to plan protected species aspects of a deep-water studies program. As industry moves into deeper, less studied areas along the continental slope, additional information is needed on the protected species occurring there. A number of human activities, the oil and gas industry being one source, have the potential to affect GOM protected species. From the standpoint of planning studies, the MMS would like to better define the most significant environmental issues for Gulf protected species, including putting petroleum industry activities in perspective with other issues. The years of effort and millions of dollars in funding for Gulfcet II and I have resulted in significant new findings which will be highlighted at this meeting. While GulfCet studies have proven to be a milestone effort in the history of GOM (as well as global) marine mammal research, how much has been accomplished in terms of addressing the identified issues listed in 1989? We think the answer to that question will emphasize the need for cooperative efforts and sharing resources and that this workshop will provide MMS and others with valuable information for planning future research.

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Dr. William Lang is a senior oceanographer at the MMS Gulf of Mexico OCS Region Office. After several years work with the Environmental Protection Agency on marine toxicology and water quality issues, he joined the MMS Studies Program, working for the Atlantic OCS Region Office in New York City. He worked on MMS's initial cetacean and sea turtle surveys conducted in the northeast and then coordinated all MMS protected species studies from headquarters in Washington, DC. After positions in environmental assessments and operations dealing with information management and environmental policy/regulations, Dr. Lang has most recently focused on protected species issues in the Gulf of Mexico. He received his B.S. from Lafayette College, his M.S. from Rutgers University, and his Ph.D. from the University of South Carolina.

Ms. Dagmar Fertl is currently a senior environmental scientist with Geo-Marine, Inc. She worked with the MMS-Gulf of Mexico Region for over five years. Ms. Fertl has over 12 years of research experience work with cetaceans in the Gulf of Mexico. While at MMS, she specialized in preparation of protected species information for NEPA documents and assisted in monitoring both of the GulfCet studies. Projects for public outreach, including a teacher's packet, cetacean poster, and web pages for the MMS site, are some of her other accomplishments while with the MMS. These efforts were recognized in the form of a Department of Interior national award in 1999. Ms. Fertl received her bachelor's degree from Trinity University and her master's degree from Texas A&M University for a study of dolphin interactions with the shrimp fishery in Texas. She has also published over 20 peer-reviewed articles on marine mammals.

ELEMENTS OF STUDIES OF PROTECTED SPECIES IN THE GULF OF MEXICO: HISTORY, PHILOSOPHY, AND RESEARCH

Dr. William E. Evans
Texas A&M University (Retired)

SURVEYS OF PROTECTED SPECIES IN THE NORTHERN GULF OF MEXICO PRIOR TO 1991

Marine ecosystems contain one-third to one-half of all species. This is not altogether surprising considering that the marine realm forms 71% of the area and 95% of the volume of the biosphere (Angel 1993). Some marine habitats, particularly coastal habitats in and around harbors, are more heavily impacted than their terrestrial counterparts (Carlton and Geller 1995). Although marine species may compose as many as half of all species, few are included in estimates of species extinction rates. Failure to secure information about loss of species and decreases in populations in a timely manner places entire ecosystems at risk (Naeen *et al.* 1994), as well as human economies dependent on these resources (Hamre 1994).

We were aware from Townsend's analysis of the 19th and early 20th century sperm whaling records that groups of sperm whales aggregated on the continental slope off of the mouth of the Mississippi (Townsend 1935). Other than that, our knowledge of cetaceans in the Gulf of Mexico was limited to data from the live capture fishery for bottlenose dolphins for the increasing number of oceanaria being developed after World War II. With the exception of data on manatees and museum records of strandings, our knowledge of protected species in the Gulf of Mexico prior to 1970 has been sketchy at best.

Until recently, relatively little was known about cetaceans, sea turtles and sea birds inhabiting deeper waters of the Gulf of Mexico. From July 1989 through June 1990, NMFS conducted aerial surveys of cetaceans and turtles along the continental slope of the north-central Gulf of Mexico in water ranging from 180-1,800 m deep (Mullin *et al.* 1991, Mullin *et al.* 1994). The objectives were to: (1) examine cetacean species diversity in the region, (2) determine the temporal and spatial distribution of cetaceans, and (3) estimate relative abundance. Over 7,000 dolphins and whales were counted during 320 sightings. The most commonly sighted groups, were: (1) Risso's dolphins, sperm whales, bottlenose dolphins, Atlantic spotted dolphins, dwarf/pygmy sperm whales, striped/spinner/clymene dolphins, pantropical spotted dolphins, beaked whales, and short-finned pilot whales. Cetacean species had a wide spatial and temporal distribution on the upper continental slope. Six species were sighted in every season (summer, fall, winter, and spring) and two additional species were sighted in each season but winter. Twelve species were sighted in summer, 10 in spring and fall, and only six in winter. Except for the short-finned pilot whale, all species sighted more than once were sighted throughout the length (east-west) of the study area. Sperm whales were found throughout the study area but were concentrated in the region near the Mississippi River delta.

THE GULFCET I PROGRAM: HOW MANY AND WHERE ARE THEY?

The most intensive and extensive survey of cetaceans in the offshore waters (100 to 2,000 m deep) of the north-central and western Gulf of Mexico was conducted jointly by Texas A&M University and the NMFS, Southeast Fisheries Science Center beginning in (GulfCet I Program, Davis and Fargion 1996). This three year study provided synoptic information on the distribution and abundance of cetaceans using both visual and acoustic survey techniques. It also provided limited information on habitat preference.

RESULTS

A total of 21,350 km of transect was visually surveyed from ships during GulfCet I. The cumulative survey effort for each season was: spring = 13,507 km; summer = 2,085 km; fall = 1,275 km; and winter = 4,483 km. It should be noted that as in Texas and probably Louisiana, oceanographically there are only two seasons in the Gulf of Mexico, summer and winter. The spring, summer and fall cruises are actually early, mid and late summer. The number of on-effort sightings each season ranged from 14 during late summer to 509 during early summer. Nineteen cetacean species were identified during 683 sightings made on-effort. Most of the survey effort occurred during the early summer, with the least effort during the late summer.

The bottlenose dolphin, pantropical spotted dolphin, and sperm whale were the most commonly sighted species; each was sighted more than 70 times. Risso's dolphin, Clymene dolphin, dwarf sperm whale, striped dolphin, and unidentified ziphiids were each sighted 21- 44 times, with the other species sighted fewer than 20 times. Average group sizes ranged from 1.2 for pygmy sperm whales and Cuvier’s beaked whale to 141 for melon-headed whales. The estimated minimum abundance of cetaceans in the GulfCet I study area was 19,198 animals. This was not inconsistent with estimates from studies prior to 1992.

Shipboard acoustic surveys were conducted concurrently with the visual surveys. A total of 12,219 km and 1,055 hours of acoustic effort was completed. On-effort acoustic sampling occurred 95% of the time. A total of 487 acoustic contacts were recorded. Of that number, 124 contacts were from 12 identified species. Sperm whales were the most commonly recorded species, accounting for 56% of identified contacts. The most commonly recorded small cetacean was the pantropical spotted dolphin with 22 contacts. A single recording of an unidentified baleen whale was made, probably a sei or Bryde's whale based on its spectral characteristics. An additional 331 contacts were made of unidentified dolphins at times when there was no visual effort, such as during poor weather and at night. There were 30 contacts with unidentified cetaceans. These were typically pulsed signals that did not sound like sperm whales or dolphins and were possibly either dwarf/pygmy sperm whales or beaked whales. Also recorded were 19 unidentified biological contacts, probably shrimp. Approximately half of the species expected to occur in the Gulf as determined by Jefferson and Shiro (1997) were recorded, including the rarely recorded clymene and rough-toothed dolphins as well as the first recording ever of Fraser's dolphin (Leatherwood *et al.* 1993). A total of 67 sperm whale on-effort, acoustic contacts were recorded along 85 transect lines. Assuming 7.3 individuals per group, the overall corrected mean sperm whale density was 2.041 individuals/1,000 $km^{2.}$ Within the 154,621 km^2 study area, the total estimated population of sperm whales is 316 individuals (265-377). On the average, one sperm whale group was detected every 161 km.

A total of 369 dolphin on-effort, acoustic contacts were made along the same 85 transect lines used to estimate sperm whale abundance. On the average, one dolphin group was detected every 31 km. The mean dolphin contact density was 1,298 groups in the study area. Using a weighted mean of 28.3 animals/group, the overall mean dolphin density was 229 dolphins/1000 km^2. The total estimated dolphin population within the study area was 36,760 animals (30,835-43,821).

A total of 49,960 km of aerial survey transect was visually sampled during eight aerial surveys. The transect kilometers sampled by survey ranged from 5,330-6,592 km and varied seasonally from 11,756-12,942 km. In total, 351 cetacean groups were sighted on-effort. The number of sightings during each survey ranged from 24 to 61 for fall 1992 and winter 1994, respectively. By season the number of sightings ranged from 49 to 109 for late summer and winter, respectively.

At least 17 cetacean species were identified during aerial surveys (each of these species was also sighted during ship surveys). Seasonally, the number of species sighted ranged from 11 in the fall to 15 in winter. Eight species were identified in all four seasons, two in three seasons, four in two seasons and four in only one season. Five species, which were each sighted 20 or more times, accounted for 71% of the identified sightings: bottlenose dolphins, pantropical spotted dolphins, Risso's dolphins, pygmy/dwarf sperm whales and sperm whales.

Overall, there were an estimated 16,986 cetaceans in the GulfCet I aerial survey study area. There were an estimated 12,690 cetaceans the first year and 20,669 the second. Most of the difference between years resulted from two winter and the two spring estimates. In both cases the point estimates were about twice as large the second year compared to the first. Cetacean abundance was about the same in winter (21,894) and spring (19,215), a little less in summer (14,959) but two to three times lower in the fall (6,051).

Pantropical spotted dolphins were the most abundant species in the aerial survey study area (5,251) followed by melon-headed whales (2,980) bottlenose dolphins (2,890) and Risso's dolphins (1,214). The sperm whale population was estimated to be 87 and pygmy/dwarf sperm whales, 176 All the other delphinid species were represented by less than 1,000 individuals each, and balaenopterids and ziphiids by less than 100 individuals each. Mean group sizes ranged from 315 for melon-headed whales to less than four for pygmy/dwarf sperm whales, sperm whales and ziphiids.

The GulfCet I Program provided limited information on habitat preference but showed the strongest correlation of species distribution with ocean depth. This study, however, failed to establish strong correlation with other oceanographic variables such as sea surface temperature, salinity, water column structure and distinctive features such as warm-core and cold-core eddies.

GULFCET II: OCEANOGRAPHIC AND BIOLOGICAL CORRELATES TO DISTRIBUTION

As early as the mid-19th century it was suspected that the location of sperm whale populations were affected by oceanographic conditions such as ocean currents (Townsend 1935).

The recent decade's developments in satellite technology and rising interest in and deployment of ocean buoy-platforms from which to monitor both surface and subsurface ocean processes are providing a growing basis for a better understanding of climate driven ocean variability and its influence on the variability of biological systems.

The objectives of the GulfCet II program were to: 1) estimate the minimum abundances of cetaceans and sea turtles and 2) characterize the distribution and habitat-associations of cetaceans and seabirds in the eastern Gulf and oceanic northern Gulf, with an emphasis on the continental slope (waters 100-2,000 m deep) (Figures 1.4 and 1.5). This study was a continuation of surveys in the oceanic north-central and western Gulf that began during the GulfCet I program and extended into the northeastern Gulf.

To accomplish these objectives, we used an integrated approach that included visual (aerial and shipboard) and acoustic (shipboard) surveys of the distribution of cetaceans, sea turtles and seabirds and simultaneous hydrographic measurements. We also used near real-time sea surface altimetry from the TOPEX/POSEIDON and ERS satellites to determine the location of hydrographic features (e.g., cyclones, anticyclones and confluence zones) during shipboard surveys. The sea surface altimetry maps enabled us to adjust the ship's course so that we could survey and sample hydrographic features that could influence the distribution of cetaceans and seabirds. Archival satellite sea surface altimetry data also allowed us to retrospectively determine the location of hydrographic features for analysis with GulfCet I cetacean sightings collected from 1992-94. In addition to characterizing hydrographic features during GulfCet II, we measured zooplankton and micronekton biomass derived from both net and acoustic sampling to indicate the amount of potential food available for higher trophic level foraging by cetaceans and seabirds. We hypothesized that hydrographic regimes in the study area had different levels of potential prey that influence cetacean and seabird distribution. We further hypothesized that these food stocks would be locally concentrated in nutrient-rich areas offshore from the Mississippi River, within cyclonic eddies, and along the high-shear edges of cyclonic eddies.

RESULTS

The physical forcing functions for ocean circulation in the north-central and eastern Gulf of Mexico are river discharge, wind stress, and the Loop Current (LC). The major river system influencing this region is the Mississippi-Atchafalaya River, with most of the outflow transported west along the coast (Cochrane and Kelly 1986). Flow on the continental shelf is largely wind-driven, with buoyancy forcing effects from low-density river water. Beyond the shelf-break, the LC largely determines mesoscale circulation. Once or twice annually, the LC sheds anticyclonic, warm-core eddies that migrate westward and spawn cyclonic, cold-core eddies. The upward flux of nutrients in cold-core eddies stimulates biological productivity in the near-surface mixed layer (Biggs *et al.* 1988, Biggs 1992).

In contrast, the LC and warm-core eddies are depleted of nutrients in the photic zone and have lower productivity. In addition, frontal zones at the periphery of eddies can entrain low salinity, high-chlorophyll shelf water and transport it off the shelf (Biggs and Muller-Karger 1994). Frontal zones may also be created during periods of northern extension of the LC.

Recent studies have used acoustic techniques to assess zooplankton and micronekton biomass as a direct or indirect index of food resources for cetaceans (Croll *et al.* 1998; Macaulay *et al.* 1995; Beardsley *et al.* 1996; Fiedler *et al.* 1998). Although there was a pronounced diel fluctuation in the vertical migration of sound-scattering organisms during this study, integrated PMB was always greater in cold-core eddies than in warm-core eddies. These former areas have a shallower MLD and lower dynamic SSH or SSH anomaly due to doming of cold, deep water. Our results show that cold-core eddies are areas of locally concentrated zooplankton and micronekton, including cephalopod paralarvae and myctophids, due to increased nutrient-rich water and primary production in the mixed layer (Biggs *et al.* 1988). The presence of cetacean species or groups is correlated with the locations of these mesoscale features. Since cold-core eddies in the northern Gulf are dynamic and usually associated with westward moving warm-core eddies, cetacean distribution is dynamic. However, with near real-time satellite remote sensing of SSH anomaly, these features can be tracked and used to predict where cetaceans may be concentrated.

In addition to cold-core eddies, ocean depth influences cetacean distribution in the northern Gulf. In earlier studies (Davis and Fargion 1996; Baumgartner 1997; Davis *et al.* 1998; Mullin *et al.* 1998), the distribution of cetaceans in the north-central and western Gulf of Mexico in waters deeper than 100 m (i.e., the GulfCet I study area) was differentiated most clearly with ocean depth. Atlantic spotted dolphins were consistently found in the shallowest water on the continental shelf and along the shelf break. In addition, the seafloor slope was less for Atlantic spotted dolphins than for any other species. Bottlenose dolphins were found most commonly along the upper slope in water significantly deeper than that for Atlantic spotted dolphins. All the other species and species categories were found over deeper ocean depths; these were Risso's dolphins, short-finned pilot whales, pygmy/dwarf sperm whales, rough-toothed dolphins, spinner dolphins, sperm whales, striped dolphins, *Mesoplodon* spp., pantropical spotted dolphins, Clymene dolphins and unidentified beaked whales (Ziphiidae). Risso's dolphins and short-finned pilot whales occurred along the upper slope and, as a subgroup, were significantly different from striped dolphins, Mesoplodon spp., pantropical spotted dolphins, Clymene dolphins, and unidentified beaked whales, which occurred in the deepest water. Pygmy/dwarf sperm whales, rough-toothed dolphins, spinner dolphins, and sperm whales occurred at intermediate depths between these two subgroups and overlapped them. Our results for the northern oceanic Gulf are consistent with these earlier results.

In the current study, cetaceans were concentrated along the continental slope and were less likely to occur in water greater than 2,000 m deep. The explanation for this is uncertain although collision of mesoscale eddies with the continental margin may further enhance primary and secondary productivity, especially along the upper slope (Griffin 1999). Skipjack, blackfin tuna, swordfish, and blue marlin have been reported by fisherman to be locally abundant in these areas (Roffer’s Ocean Fishing Forecasting Service). The presence of large, apex-predators such as tuna, billfish and cetaceans indicates reliable food resources along the continental slope.

In the north-central Gulf, an additional factor may be the narrow continental shelf near the mouth of the Mississippi River. Low salinity, nutrient-rich water is entrained by eddy circulation and transported over the continental slope. This creates a deep-water environment with enhanced primary and secondary productivity, which may explain the presence of a resident population of endangered sperm whales within 25 km of the Mississippi River delta. Although the diet of sperm whales in the northern Gulf is unknown, squid are typically the most important component followed by fish (Berzin 1971). Sperm whales in the north-central Gulf occur along the mid-to-lower slope (Collum and Fritts 1985; Davis *et al.* 1998) in areas with lower dynamic SSH, higher PMB and shallower MLD. The occurrence of sperm whales in similar ocean depths (200 to 1,500 m; Whitehead *et al.* 1992) and in areas of increased productivity along frontal systems (Waring *et al.* 1993; Griffin 1999) has been observed off the continental shelf of Nova Scotia and the northeastern United States. In the South Pacific, sperm whales occur in areas with high secondary productivity and steep underwater topography (Jaquet and Whitehead 1996; Jaquet, Whitehead and Lewis 1996). However, the results of a Chi-square test that combined GulfCet I and GulfCet II sightings for the entire oceanic northern Gulf showed a random distribution with respect to oceanographic features. This indicates that factors other than food distribution may influence the sperm whale distribution (Jaquet and Whitehead 1996; Jaquet, Whitehead and Lewis 1996). As with sperm whales, similar correlations with lower dynamic SSH, higher PMB and shallower MLD were obtained for the squid-eaters and oceanic stenellids, although squid-eaters occurred along the upper slope and stenellids along the lower slope and in water greater than 2,000 m deep (Jennings 1982).

Unlike the other cetacean species or groups, the distribution of bottlenose dolphins and Atlantic spotted dolphins was not correlated with the cold-core eddies that occur in deeper waters beyond the shelf break. The preference of these two species for the shallow waters of the continental shelf and upper slope generally precludes them from feeding around cold-core eddies. The same appears to be true of Bryde's whale, which have been sighted in the northeastern Gulf in water 100 m deep (Davis *et al.* 1998; see also Chapter 4) and along the shelf break (Mullin *et al.* 1998). We have little information on the environmental variables that influence the distribution of these species or their prey because hydrographic surveys have concentrated on deeper waters beyond the continental shelf.

CONCLUSIONS

Cetaceans in the northeastern and oceanic northern Gulf of Mexico are concentrated along the continental slope in or near cold-core eddies. These eddies are mesoscale features with locally concentrated zooplankton and micronekton due to increased nutrient-rich water and primary production in the mixed layer. The exceptions were bottlenose dolphins, Atlantic spotted dolphins and possibly Bryde's whale that typically occur on the continental shelf or along the shelf break outside of major influences of eddies. Low salinity, nutrient-rich water from the Mississippi River also contributes to enhanced primary and secondary productivity in the north-central Gulf and may explain the presence of a resident population of endangered sperm whales south of the delta. Since cold-core eddies in the northern Gulf are dynamic, cetacean distribution may change in response to the movement of prey associated with these hydrographic features.

Sounds associated with offshore oil exploration in the Gulf of Mexico are becoming increasingly common. The peak intensity of seismic exploration pulses recorded during GulfCet II was found to be typically below 250 Hz, with an average peak intensity at 82 Hz. The average intensity of pulses was found to be 8.4 dB above ambient, more than double ambient levels. However, there was no significant difference in the sighting frequency between the different acoustic levels examined for GulfCet I and II, contrary to previous findings (Mate *et al.* 1994). In addition, the observed distribution of cetaceans did not differ significantly with seismic sound intensity for different hydrographic regions. However, this study did not examine smaller-scale behavioral impacts. While the GulfCet I and II Programs offered an opportunity to examine the potential effects of human acoustic perturbation on the large-scale distribution of local cetacean populations, they lacked the ability to control for both the acoustic level and the hydrographic region. To better understand the potential impact of man-made noise on local cetacean populations, a systematic study is needed that can control acoustic variation in different hydrographic features. Ideally, such a study would examine small-scale behavioral changes in addition to distribution.

Loggerhead, Kemp's ridley, and leatherback sea turtles inhabited shelf waters but loggerheads were by far the most abundant. (Kemp's ridley sea turtles are very difficult to see due to their small size, and these results probably do not accurately represent their abundance relative to loggerheads.) Loggerhead sea turtles were widely distributed in shelf water with similar abundance during both summer and winter.

The three cruises provided more information on seasonal distribution and abundance of seabirds in the Gulf of Mexico. The relationship between hydrographic environment and species diversity was examined. We found the highest species diversity in the cyclone and lowest on the continental shelf. Several species exhibited affinities to specific hydrographic environments. Pomarine jaegers and black terns preferred the MOM area. Audubon's shearwaters were more likely to be present in the cyclone, and band-rumped storm-petrels in "other margin" areas. Species' presence was analyzed with models incorporating bottom depth, sea-surface properties, and plankton standing stocks using generalized additive models. Results suggest that the presence of laughing gull, Audubon's shearwater, band-rumped storm-petrel and bridled tern presence was best predicted by indicators of plankton-standing stock, using sea surface chlorophyll concentrations and PMB as predictor variables. For laughing gull, black tern and sooty tern, sea surface temperature and salinity best predicted presence. Models incorporating sea surface height and bathymetry predicted pomarine jaeger and Audubon's shearwater presence.

DISCUSSION: WHAT IS THE NEXT STEP?

The answers to this question vary with every vested interest group, but I believe that the first step is for someone to take full responsibility for the Gulf of Mexico as publicly owned, not necessarily renewable common properties. The major tasks ahead are to develop the necessary multidisciplinary capabilities of the scientific community to use these new tools to conduct appropriately scaled research on causal processes and sequences of physical and ecological responses. Then the most effective, cost-efficient mechanism for monitoring and managing the entire array of resources, mineral and biological should be designed with the future in mind. This then needs to be implemented as efficiently and effectively as possible in the face of the inertia of the present system. This will not be an easy task, but it is now under way. Don't we have the necessary system already? Clearly the answer is no.

Progress in our understanding of protected species in the Gulf of Mexico from 1970s to the present has grown. We have gone from just knowledge of presence of certain protected species, to a good understanding of numbers, distribution and now an understanding of habitat, not only for cetacea, and sea turtles but sea birds. What is the next step? Basically our purpose here is to concentrate on determining the potential impact of oil and gas activities on these protected species. Are we at the point where we know enough that we can now enter into a monitoring phase? How much monitoring is enough? Can satellite oceanographic data and aerial surveys define the dynamic features of the Gulf well enough to detect significant changes in species numbers and distribution?

A workshop on the Protected Species of the Gulf of Mexico was convened under contract with the United States Environmental Protection Agency, Gulf of Mexico Program. This workshop was held on 24 and 25 April 1996. Some of the recommendations from that workshop are worthy of consideration here with modification:

- Enhance existing research and monitoring programs that assist in the identification of critical ecosystem components and in the preservation of the full range of distinct ecosystems. Areas identified must have sufficient contiguity to insure adequate gene flow and population numbers. These will include identifying, censusing, and complex mapping (both geographic and ecological) targeted marine species and associated physical data, necessary to delineate ecosystem types. Simple compilations of statistics on a handful of popular species will be wholly inadequate. It will must include identifying habitats common to the wide range of protected species that require special attention and preservation, as well as establishing protocols to determine the most cost-effective solutions.

- Develop both theory and data necessary to implement both large and small scale computational models designed to make specific predictions of loss or changes in biodiversity within the Gulf of Mexico. These models should commence with current data from recent assessments and other ongoing monitoring activity. Models should then grow with refinement to include all other species.

- Improve quantitative methods of analyzing existing information on biodiversity to enhance its predictive capabilities, particularly those evaluating spatial data and frequency distributions in the presence of sparse sampling.

- Increase interagency efforts to identify and disseminate in electronic form currently existing data, "gray literature", and other information pertinent to the study of biodiversity, particularly that relevant to the documentation of historical trends essential to the determination of rates of species and population loss and gain both Gulf-wide and locally.

- Enhance research training opportunities for new scientists, students, and the general public that are critical to increased programmatic and scientific capabilities in the future. This is of special concern because human-induced stresses on Gulf ecosystems are greatly increasing at a time when taxonomic expertise is rapidly declining. Should this trend continue un-addressed, it will soon be impossible for scientifically sound studies to be conducted or rational management policies to be implemented. Lack of such studies and policies would place both public health and the economy at risk.

- Improve facilities used to study biodiversity, particularly research collections that serve as the principal sites for the creation and dissemination of new primary data of importance to both applied and basic science, as well as to general economic development of biodiversity resources.

- Improve ties between research collections and personnel within the academic community that utilize such collections and federal and state management, preservation, and monitoring activities of federal and state agencies so that the archival value of research collections can be better utilized in ongoing management efforts to study and conserve biodiversity.

- Improve research collections to facilitate state-of-the-art training sites for a wide range of students and professionals, who must become far more knowledgeable of existing biodiversity, if they are to collectively ensure a sustainable future. Such training should not only include biologists, but should be designed to applicable to computer scientists, construction engineers, architects, city and industrial planners, lawyers, law enforcement personnel, real estate and housing developers, and others actively involved in land use and management.

- Insure that routinely funded ecological and oceanographic monitoring of all kinds. This should include environmental assessments associated with environmental impact statements, particularly those that involve environmentally sensitive areas. Most such impact statements are notoriously poor in establishing the identity of potentially impacted species.

- Develop quantitative research and sampling methods that will permit marine organisms to be studied with the minimum of perturbation, while maximizing the accuracy of observation. These should include on-line acquisition and monitoring of certain key data, including those involving measurement of the extent and quality of existing habitat and population numbers of carefully chosen species. In the case of the MMS Eastern Planning Area, sperm whales are a good candidate.

- Information is needed on the movements, diving behavior and site fidelity of endangered sperm whales along the continental slope southeast of the Mississippi River delta. Satellite telemeters should be attached to sperm whales to examine seasonal movements and preferred foraging depths. Skin biopsy samples should be collected to determine how closely related Gulf sperm whales are to those from the adjacent Atlantic Ocean and Caribbean Sea. A photo-identification study in this region should be conducted to assess the site fidelity of individual whales.

- Fund studies of the economic impacts of changes and loss of biodiversity in the Gulf of Mexico.

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THE MARINE MAMMAL PROTECTION ACT

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This paper summarizes the provisions of the Marine Mammal Protection Act (MMPA) of particular relevance to oil and gas exploration and development in the northern Gulf of Mexico. Enacted in October 1972, the MMPA established a general moratorium on the taking of marine mammals in areas under U.S. jurisdiction. It defines the term “take” to mean “to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal.” Amendments to the MMPA in 1994 define the term “harassment” to mean “any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or a marine mammal stock in the wild; or (ii) has the potential to disturb a marine mammal or a marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.”

The Act provides that the moratorium on taking can be waived if certain conditions are met—e.g., if available data are sufficient to reasonably conclude that the affected species or population is within its optimum sustainable population (OSP) range and will not be “disadvantaged” by the proposed taking. The Act also provides that permits may be issued to allow taking of marine mammals for purposes of scientific research and public display when certain conditions are met. The moratorium on taking does not apply to taking of marine mammals by Alaska Natives for subsistence and handicraft purposes, when the taking is not wasteful.

The conditions for obtaining a waiver of the taking moratorium are procedurally burdensome and, as a consequence, few waivers have been sought or granted. The Act was amended in 1981 and again in 1986 to make it easier to obtain taking authorization when only small numbers of animals will be taken, the taking is unintentional, and the effects on population size and productivity will be negligible.

Section 101 (a)(5)(A) of the Act, as amended in 1986, directs the Secretaries of Commerce and the Interior (the National Marine Fisheries Service and the U.S. Fish and Wildlife Service) to allow the taking of small numbers of marine mammals incidental to activities (other than commercial fishing covered by other provisions of the Act) for periods of up to five years if, after notice and opportunity for public comment, the Secretary

(i) finds that the total of such taking during each five-year (or less) period concerned will have a negligible impact on such species or stock…; and

(ii) prescribes regulations setting forth

(I) permissible methods of taking pursuant to such activity, and other means of effecting the least practicable adverse impact on such species or stock and its habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance, and on the availability of such species or stock for subsistence uses [by Alaska Natives]; and

(II) requirements pertaining to the monitoring and reporting of such taking

The House of Representatives Report that explained the 1981 amendments referenced the dictionary definition of “negligible” and indicated that the term “negligible impact” was intended to mean an impact “so small or unimportant or of so little consequence as to warrant little or no attention.” The explanation suggests that the negligible impact standard is intended to be more restrictive than the “no significant impact” standard in the National Environmental Policy Act (NEPA). Thus, a finding of no significant impact under the NEPA would not necessarily mean that the activity in question would have a negligible impact on marine mammals and that taking authorization under the MMPA is not required.

All forms of incidental taking, including lethal taking, may be authorized under section 101 (a)(5)(A) of the MMPA. A new provision, section 101 (a)(5)(D), was added to the Act in 1994 to provide a streamlined mechanism for authorizing small takes of marine mammals when the taking is by incidental harassment (unintentional disturbance) only.

Authorizations under section 101 (a)(5)(A) involve a two-step process: (1) promulgation of a finding that the incidental taking will have negligible effects and regulations setting forth permissible methods of taking and requirements for monitoring and reporting the taking; and (2) issuance of letters of authorization (LOAs) for particular activities in accordance with the regulations. Promulgation of regulations can take more than six months.

Authorization of incidental harassment under section 101 (a)(5)(D) does not require promulgation of regulations. Rather, the responsible regulatory agency is required to determine, within 45 days of receiving an application, whether the application makes the required showings, and, if it does, to publish a proposed authorization and notice of availability of the application for public comment in the *Federal Register* and in newspapers and appropriate electronic media in communities in the area where the taking would occur. Then, after a 30-day comment period, the agency has 45 days to make a final determination on the application.

Authorizations under section 101 (a)(5)(A) may be issued for periods up to five years. Authorization under Section 101 (a)(5)(D) may be issued for no more than one year. In both cases, authorizations may be renewed according to the specified procedures. Swartz and Hofman (1991) provide an assessment of the intent and provisions of section 101 (a)(5)(A) as they relate to offshore oil and gas development and other activities.

Given the aforementioned provisions of the Marine Mammal Protection Act, it follows that the participants in this workshop should keep three basic questions in mind. They are

1. given the results of research and monitoring programs in the Gulf of Mexico or elsewhere, is there reason to believe or to suspect that oil and gas exploration and development activities in the northern Gulf of Mexico may be resulting in the taking of any species of

marine mammal (i.e., be causing the death, injury, or disruption of biologically important behavior of any marine mammal species)?

2. if taking may be occurring, are the effects on the distribution, abundance, or productivity of the affected species or populations negligible or non-negligible? and

3. if there are uncertainties concerning the nature or significance of the possible effects, what research or monitoring is needed to resolve the uncertainties?

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THE ENDANGERED SPECIES ACT AND GULF OF MEXICO MARINE SPECIES

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This paper provides a framework understanding of the Endangered Species Act (ESA) and of how the statute shapes the responsibilities of all the players who may be affecting endangered and threatened marine species in the Gulf. It is hoped that this understanding will be useful to developing recommendations for future scientific activities relating to MMS's management of oil and gas development.

PLAYERS

The ESA's requirements for managing listed species include a wide-range of players. The National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (FWS) are the federal agencies charged with primary management responsibility for listed species. In the Gulf of Mexico, six species of great whales, five species of sea turtles, and the Gulf sturgeon are listed as endangered or threatened and under NMFS jurisdiction. All other federal agencies with activities in the Gulf also have duties within their own range of authorities to conserve listed species and to minimize the impacts of their actions on listed species. The MMS, U.S. Army Corps of Engineers, the Air Force, and the Navy are some of the major federal actors in the Gulf, in terms of the breadth and scope of their activities. Other federal agencies, such as the U.S. Coast Guard, the Environmental Protection Agency, the U.S. Geological Survey, the National Park Service, and the Federal Energy Regulatory Commission, also have roles in studying or protecting listed marine species, or conducting or permitting activities that may affect them. Section 6 of the ESA allows states to form cooperative agreements with NMFS to protect and manage endangered and threatened marine species, although none of the coastal Gulf states have yet done so. Industry, of course, is also heavily involved with protected species activities, both through their regulatory requirements and through their own initiatives. We also depend on academia to conduct much of the critical scientific research to understand these species' threats and needs. Lastly, the ESA has special provisions which allow "any person" to become involved in endangered species issues.

IMPORTANT PARTS OF THE ESA

Section 4 - Determination of Endangered and Threatened Species

Section 4 is the starting point for the protection and recovery of a species. It specifies the procedures and requirements for listing a species as threatened or endangered. It also lays out how to designate critical habitat for a species. Critical habitat, as used in the ESA, has a particular meaning, and then only has meaning in relation to one other section of the ESA. No critical habitat has been designated for listed marine species in the Gulf. Once species are listed, section 4 requires that recovery plans be created for most species. The recovery plans set out goals to be achieved to bring about a species' recovery and de-listing. They also recommend the tasks needed and specify who is to accomplish them. (Recovery plans have been completed for the five species of Gulf sea turtles, the Gulf sturgeon, and the blue whale.) Lastly, when species are listed as threatened (but not endangered), special regulations can be enacted under section 4(d) – "a 4(d) rule" – that lay out what protections these threatened species require. These 4(d) rules are commonly used to extend most of the ESA's full protections for endangered species to threatened species, while carving out a few exceptions. One well-known application of a 4(d) rule in the Gulf of Mexico is the exception that allows shrimpers incidentally to capture threatened sea turtles, as long as they use turtle excluder devices.

Section 9 - Prohibited Acts

Virtually every law has its list of prohibitions, and the ESA is no exception. The one of primary concern is the blanket prohibition of any kind of "take" of an endangered species. The definition of take in the ESA includes "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect" or to attempt to do any of those. Importantly, the take prohibition includes non-intentional, or incidental, takes as well. Section 9 also prohibits any violations of the special protective regulations for threatened species (4(d) rules).

Section 7 - Interagency Cooperation

The ESA includes special duties and responsibilities for all federal agencies to help carry out the purposes of the ESA. These are spelled out in section 7. Section 7 applies only to federal agencies, but it is probably the most relevant part with respect to our meeting. Therefore, I will focus briefly on two of section 7's most important parts.

All federal agencies have a duty to take positive actions to conserve endangered and threatened species. Section 7(a)(1) of the ESA provides that "…federal agencies shall, in consultation with and with the assistance of [NMFS or FWS], utilize their authorities in…carrying out programs for the conservation of threatened and endangered species… ." This language has long been considered to represent simply a generalized policy, rather than a concrete obligation. A recent court ruling, however, has emphasized that federal agencies do have an affirmative responsibility to take action to conserve listed species (see *Sierra Club vs. Glickman,* U.S. 5th Circuit Court of Appeals, Sept. 1998).

Federal agencies have a further duty to examine the effects of their actions on listed species; this process is called section 7 consultation. Section 7(a)(2) of the ESA requires every federal agency, in consultation with NMFS and/or FWS, to ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any listed species. As part of the consultation process, NMFS would review the agency action and issue a "biological opinion" about whether jeopardy to any listed species is likely. If a "no-jeopardy" finding is reached, then the biological opinion would also include an incidental take statement (ITS) that would authorize a small level of incidental take of listed species, while requiring the federal agency or their permit applicant to take specified measures to reduce the impact of the take. For listed species of marine mammals, incidental take can only be authorized if the more stringent requirements of section 101(a)(5) of the

Marine Mammal Protection Act (MMPA) have been met as well. An ITS provides an important exception to the prohibition on takes in section 9, as long as the terms and conditions of the ITS are implemented. If an agency action is determined likely to jeopardize any listed species, then the activity may not proceed and no incidental take would be authorized, unless a no-jeopardy alternative is specified. Very few agency actions result in jeopardy biological opinions, however. The section 7 consultation process actually provides for a great deal of flexibility and cooperation between the action agency and NMFS or FWS, so impacts may be identified and minimized in advance, to prevent jeopardy to listed species and adverse changes to the project. Section 7 consultation can also be a fairly dynamic process; many consultations are re-opened and modified, as the projects change or new information on the impacts of the projects or the needs of the species becomes available.

NMFS and MMS have completed two important consultations relating to Gulf of Mexico marine species. In a July 1988 biological opinion, NMFS concluded that oil rig abandonment and explosive rig removals in the OCS were not likely to jeopardize any listed species under NMFS jurisdiction. That opinion considered the effects of a “generic” explosive rig removal, in which the manner of the explosive removal was constrained to what was then considered typical and relatively safe for marine animals. The requirements of the ITS focus on monitoring and minimizing the impacts of individual removals. The opinion is over 10 years old and is still in effect, but NMFS and MMS have been discussing reinitiating the consultation to also consider the effects of other, non-generic blasting configurations. The 1988 opinion also doesn’t apply to rig removals in the territorial sea, where removal permits are issued by the states or the Corps of Engineers. More recently, in January 1998, NMFS issued a no-jeopardy biological opinion on MMS’ 5-year lease sale plans for the Western and Central Gulf Planning Areas. Biological opinions have to consider all the direct and indirect effects of an action, so this opinion considered all OCS oil and gas exploration and development activities (except rig removals). Since the scope of the opinion was so wide, the requirements of the ITS focus more on monitoring the Gulf-wide status of affected species (specifically their overall numbers and health) and on addressing data needs.

Section 10 - Exceptions

Section 7 consultation can provide for an important exception to the prohibition on incidental take of listed species, but section 7 does not apply to non-federal activities, nor to cases of directed take of listed species. Section 10 of the ESA provides for permits that can authorize those types of takes. Permits can be granted for the directed take of a listed species for scientific research purposes and for activities to enhance the species’ survival (“10(a)(1)(a) permits”). Permits can be granted to non-federal applicants, who do not have access to section 7, to incidentally take listed species during the course of an otherwise lawful activity (“10(a)(1)(b) permits”). The applicants are required to minimize and mitigate their impacts, often by setting aside habitat, and these permits are commonly called Habitat Conservation Plans (HCPs). HCPs are not widely used in the marine environment, because many activities are federally authorized and section 7 would apply.

Section 11 - Penalties and Enforcement

The ESA allows violators to be fined through civil proceedings or to be criminally prosecuted, with maximum penalties of $25,000 or $50,000, respectively. In addition to penalties that can be sought by the government, the ESA includes a citizen suit provision in section 11(g). Any person may sue any other person, including the U.S. government, for violating any section of the ESA. These suits may seek an injunction to stop an activity that violates the ESA. A common use of these suits is to compel federal agencies to conduct section 7 consultation. The citizen suit provision has been heavily used in the courts, primarily by environmental NGOs.

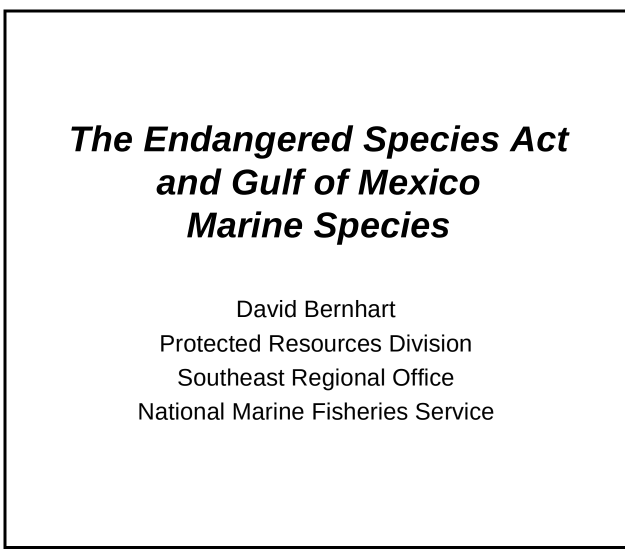
Section 17 - Construction with the MMPA

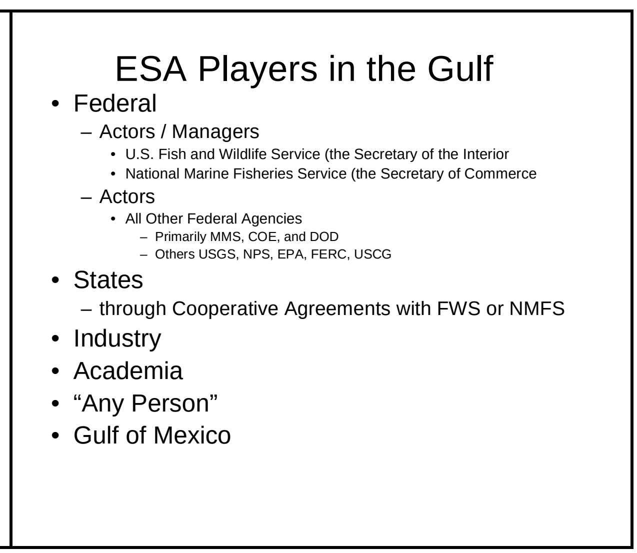
Probably the most obscure section of the ESA is section 17, but it is relevant to our meeting because one of the more important marine mammals in the Gulf—the sperm whale—is protected by both the MMPA and the ESA. Section 17 states that the ESA does not take precedence over the MMPA, where the MMPA's provisions are more restrictive. In other words, for listed species of marine mammals, both acts must be complied with, including the most restrictive requirements.

PRESENT GOALS

For MMS, the most immediate needs are to implement the requirements of the existing biological opinions and incidental take statements. Looking to the future, information will be needed to support consultations on changes to existing activities, such as different methods for oil rig removals, or for consultations on new activities, such as expansion of oil and gas development into the eastern Gulf.

SLIDE SHOW





Endangered and Threatened Species Under National Marine Fisheries Service Jurisdiction

blue whale	*Balaenoptera Musculus*	Endangered
fin whale	*Balaenoptera physalus*	Endangered
humpback whale	*Megaptera novaeangliae*	Endangered
right whale	*Eubalaena glacialis*	Endangered
sei whale	*Balaenoptera borealis*	Endangered
sperm whale	*Physeter macrocephauls*	Endangered
green sea turtle*	*Chelonia mydas*	Endangered/ Threatened
hawksbill sea turtle*	*Eretmochelys imbricata*	Endangered
Kemps ridley turtle*	*Lepidochelys kempii*	Endangered
leatherback turtle*	*Dermochelys coriacea*	Endangered
loggerhead sea turtle*	*Caretta caretta*	Threatened
gulf sturgeon*	*Acipenser oxrinchus desotoi*	Threatened

* Joint jurisdiction with U.S. Fish and Wildlife Service

Important Parts of the ESA

- Section 4 - Determination of Endangered and Threatened Species
- Section 7 - Interagency Cooperation
- Section 9 - Prohibited Acts
- Section 10 - Exceptions
- Section 11 - Penalties and Enforcement

Section 4 of the ESA

- How to list species as endangered or threatened
- How to list critical habitat
- Recovery Plans required
- Protective regulations for threatened species can be issued

Section 9 of the ESA

- “Take” of endangered species is prohibited
  - Includes to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt
  - Includes incidental take as well
- Violation of protective regulations for threatened species is prohibited

Section 7 of the ESA

- Applies to federal agencies
- 7(a)(1) - Conservation Requirement
  - “. . .Federal agencies shall, in consultation with and with the assistance of the Secretary, utilize their authorities in . . . carrying out programs for the conservation of threatened and endangered species . . .
- Positive obligation, recently verified by the courts

Section 7 of the ESA

- 7(a)(2) - Consultation Requirement
  - Requires every Federal agency, in consultation with NMFS and/or FWS, to ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of any listed species
- NMFS/FWS reviews the “agency action” and issues a Biological Opinion whether jeopardy is likely
- No-Jeopardy Biological Opinions include an Incidental Take Statement
  - Authorizes a small level of incidental take of listed species
  - Requires measures to minimize the impacts of the take
  - For Marine Mammals, take must be authorized through MMPA, too
- Jeopardy actions may not go forward unless a no-jeopardy alternative is found

Section 7 of the ESA

- Oil Rig Abandonment / Explosive Rig Removal
  - July 1988 No-Jeopardy Biological Opinion
  - Considered effects of a “generic” rig removal process in the OCS
  - ITS requirements focus on monitoring removals
  - Doesn’t apply to territorial sea or non-generic removals
  - Informal consultation has been ongoing to consider non-generic removals
- Lease Sales
  - January 1998 No-Jeopardy Biological Opinion
  - Considered 5-year lease sales in Western and Central Gulf
    - Includes resulting OCS activities (except explosive rig removals)
  - ITS requirements focus on species monitoring (numbers and health) and data needs

Section 10 of the ESA

- 10(a) - Take Permits
- 10(a)(1)(a) - Authorizes scientific research or enhancement activities
- 10(a)(1)(b) - Authorizes incidental take of listed species
  - Available to non-Federal applicants
  - Requires applicant to minimize and mitigate impacts
  - Often called Habitat Conservation Plans (HCPs)
  - Not widely used in the marine environment, because Section 7 affects most activities

Section 11 of the ESA

- Sets penalties for violations
  - Civil $25K
  - Criminal $50K
- Authorizes Citizen Suits
  - Any person may sue any person (including the U.S. Government) for violating the ESA
  - Can include violation of any section

Section 17 of the ESA

- The ESA does NOT take precedence over more restrictive provisions of the MMPA

BIOLOGY

GULFCET I AND II – CETACEANS, SEA TURTLES AND HABITAT CONSIDERATIONS

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The GulfCet I and GulfCet II programs resulted from cooperative research between the MMS Gulf of Mexico Region, the NMFS Southeast Fisheries Science Center and Texas A&M University. GulfCet I, 1991-95, was a seasonal study of cetacean and sea turtle distribution in U.S. continental slope waters (100-2,000 m) of the north-central and northwestern Gulf (Davis and Fargion 1996). GulfCet II, 1996-98, was a continuation of this seasonal research and focused on slope waters of the northeastern Gulf and selected continental shelf waters (<100 m) south of the western Florida Panhandle. An additional aspect of GulfCet II was a replication of spring abundance surveys of the oceanic northern Gulf conducted by the SEFSC from 1991-1994 (Hansen *et al.* 1995). In addition to GulfCet surveys, the SEFSC has conducted fall aerial surveys of the entire continental shelf in the northern Gulf (Blaylock and Hoggard 1994) and a summer ship survey of the western Florida continental shelf. Distribution and abundance data were collected during both aerial and ship surveys using line-transect methods (Buckland *et al.* 1993).

To characterize cetacean habitats during GulfCet I and II, hydrographic data were collected during ship surveys. Two ship surveys were conducted during GulfCet II to simultaneously collect cetacean location data and data on the marine environment and zooplankton biomass (acoustic and net sampling) in an area containing a cyclone-anticyclone. Satellite remote sensing data for sea surface height (SSH) anomaly and GulfCet I and II cetacean sighting locations were combined to examine the relationship between cetacean distribution and hydrographic features. Relationships to ocean depth and ocean depth gradient were also examined.

CETACEAN DIVERSITY, ABUNDANCE AND DISTRIBUTION

In the northern Gulf, the continental shelf and shelf-edge is inhabited almost exclusively by bottlenose and Atlantic spotted dolphins. Bottlenose dolphins are widely distributed in all shelf waters but genetic studies indicate species level differences between nearshore and offshore animals (LeDuc and Curry 1998). Atlantic spotted dolphins usually are not found in waters less than about 10 m deep, and while widely distributed, appear to be more common off Florida.

The primary findings from GulfCet I and II indicate that the oceanic cetacean community is composed primarily of tropical species that usually inhabit deep waters (Jefferson *et al.* 1993). The oceanic studies generally indicate the following:

1. Cetaceans are diverse. There are at least 20 species that range from being uncommon to very abundant. Other species with records from the Gulf are probably very rare (e.g., humpback, minke, blue, sei, right whales) or extralimital (Sowerby's beaked whale). There are no valid records of common dolphins from the Gulf (Jefferson 1995).

2. The pantropical spotted dolphin is the most abundant species with an estimated minimum of 30,000-40,000 dolphins. The abundances of both spinner dolphins and Clymene dolphins ranged from 6,000-12,000. The abundances of bottlenose dolphins, Risso's dolphins, striped dolphins, and melon-headed whales ranged from 1,500-5,500, and those of other species, <1,000.

3. The sperm whale (400-550 animals) and Bryde's whale (<50 animals) are the only large whales routinely sighted in the Gulf. While less abundant than the delphinids, the sperm whale may be at least as ecologically significant because of its size and was estimated to comprise about 44% of the cetacean biomass in the oceanic northern Gulf.

4. Most species are present throughout the year and, at least in spring, are widely distributed in the oceanic northern Gulf.

5. The abundance of some species (e.g., dwarf/pygmy sperm whale, Risso's dolphin, bottlenose dolphin, pantropical spotted dolphin) may vary seasonally in continental slope waters.

6. The abundance of some species appears to vary east to west. Bryde's whales, false killer whales, pantropical spotted dolphins and spinner dolphins have been sighted more frequently to the east of the Mississippi River delta. Conversely, short-finned pilot whales, melon-headed whales, and Clymene dolphins are typically sighted to the west of the river.

OCEANIC CETACEAN HABITATS

Of six hydrographic and physiographic features used to define species habitat during GulfCet I, only bottom depth provided the clearest differentiation. Atlantic spotted dolphins were consistently found in the shelf break region. Bottlenose dolphins generally inhabited waters of the shelf break to upper slope. Risso's dolphins and short-finned pilot whale occurred along the mid- to upper slope. On average, pygmy/dwarf sperm whales, spinner dolphins and sperm whales occurred at intermediate depths. Striped dolphins, beaked whales, pantropical spotted dolphins and Clymene dolphin inhabited the deepest waters (Davis *et al.* 1998). With a few exceptions, Bryde's whales have been found along a narrow corridor near the 100 m isobath in the northeastern Gulf. Killer whales range throughout the northern Gulf, but most sightings occurred in a broad region just southwest of the Mississippi River Delta. Results from the combined GulfCet I and II data were similar to GulfCet I. While distributed throughout the oceanic northern Gulf, Baumgartner (1997), demonstrated that

Risso's dolphins have a core habitat along the upper continental slope defined by depth and depth gradient. This core habitat makes up about 2% of the entire Gulf.

Cetaceans in the northeastern and oceanic northern Gulf were concentrated along the continental slope in or near cyclones. These eddies are mesoscale features with locally concentrated zooplankton and micronekton stocks that appear to develop in response to increased nutrient-rich water and primary production in the mixed layer. The exceptions were bottlenose dolphins, Atlantic spotted dolphins and possibly Bryde's whales. These species typically occur on the continental shelf or along the shelf break outside of the major influences of eddies. While endangered sperm whales are widely distributed in the northern Gulf, there appears to be a resident population south of the Mississippi River delta. This may be explained by low salinity, nutrient-rich water from the Mississippi River, which may also contribute to enhanced primary and secondary productivity in the north-central Gulf. However, since cyclones in the northern Gulf are dynamic, cetacean distribution will undoubtedly change in response to the movement of prey associated with these hydrographic features.

SEA TURTLE DIVERSITY, ABUNDANCE AND DISTRIBUTION

Five species of sea turtles occur in the Gulf: leatherback, loggerhead, Kemp’s ridley, green and hawksbill. All five species have been sighted during SEFSC fall shelf and GulfCet aerial surveys, but results pertain only to large, probably adult, turtles visible from aircraft at the surface of water. In shelf waters loggerheads are widely distributed throughout the northern Gulf but the frequency of sightings increased dramatically in the eastern Gulf. The density of loggerheads in the northeastern Gulf was about 20 times greater in shelf waters (4.08 turtles/100 km^2) compared to slope waters (0.20 turtles/100 km^2). Summer and winter densities of loggerheads were similar in shelf waters but were about 10 times larger during winter in slope waters. Loggerheads were about four times more abundant in continental slope waters in the northeastern Gulf compared to the north-central and northwestern Gulf. The majority of leatherback sightings in shelf waters were just north of DeSoto Canyon in the northeastern Gulf. Leatherbacks were widely distributed in slope waters throughout the northern Gulf, but there were areas of high concentrations of turtles that were variable in distribution. The overall density of leatherbacks was 0.24 turtles/100 km^2 in slope waters of the northeastern Gulf and 0.18 turtles/km^2 in the northwestern Gulf. Seasonal densities of leatherbacks were similar in slope waters west of Mobile Bay but more variable to the east. Sightings of hawksbill and green turtle occurred in shelf waters primarily off southern Florida.

ON-GOING CETACEAN STUDIES

In 1998, the MMS and the SEFSC initiated a three-year cetacean abundance monitoring program of U.S. Gulf shelf and oceanic waters (the program has been extended through FY 2002). This program provides for ship surveys of oceanic waters during spring, and shelf waters during the fall. These surveys are “piggy-backed” on SEFSC ichthyoplankton surveys and, therefore, costs are primarily limited to observer salaries. The fall 1998 shelf survey was heavily impacted by hurricanes but the spring 1999 oceanic survey was extremely successful.

FUTURE CETACEAN RESEARCH NEEDS

Research with Existing Abundance and Distribution Data

1. The current abundance estimates of cetacean species for the oceanic northern Gulf may be biased because the survey effort does not appear be completely random or uniform in distribution. More accurate abundances may be obtained by making area-weighted estimates from a grid of cells. Similarly, current distribution plots may not represent the true distribution of animals due to the distribution of effort and variability in group-size. Density contours could be generated from the grid for common species which would provide more useful information concerning the area where each species would most likely be encountered.

2. To provide more precise estimates of abundance and improve the probability of detecting changes in abundance for a species over time, an attempt could be made to use data only from a species' primary habitat for estimates (e.g., Reilly and Fielder 1994). At this time, depth ranges (and perhaps longitude) could be considered.

3. Aerial survey results from GulfCet I and II indicated that abundances of several species may change seasonally; however, most differences were not statistically different. A recent more powerful statistical test could be employed to reexamine these seasonal data for significant differences (Forney and Barlow 1998).

4. While all of the current abundance estimates are negatively biased due to perception bias (animals missed by observers) and availability bias (animals beneath the surface), the perception bias is probably greater for cryptic species such as beaked whales and dwarf/pygmy sperm whales. Reanalyses of data using only excellent sighting conditions would give a better indication of the abundance of these species relative to others.

Suggested Future Research

1. Research the genetic stock structure, movements, diving behavior and site fidelity of endangered sperm whales.

2. Continued monitoring of cetacean populations in the northern Gulf during the NMFS ichthyoplankton surveys.

3. Research on the effects of seismic sounds on cetaceans.

4. Initiate a GulfCet III Program for the U.S. water south of Tampa Bay and the southern Gulf of Mexico (south of the U.S. Economic Exclusive Zone), including the Straits of Florida.

5. Research on cetacean habitat-associations should continue. If shifts in a species' distribution occur, a better understanding of habitat will be needed.

6. Research on genetic stock structure of all cetaceans should be given added emphasis. The MMPA mandates that stocks of cetaceans be protected. Of particular interest are Bryde's whales which have displayed considerable local variation world-wide (Dizon *et al.* 1995) and appear to have a limited distribution in the northern Gulf.

7. Research to estimate absolute abundances. That is, correct minimum abundances for perception bias (observer bias) and availability bias (beneath the surface) with data from independent observer experiments and dive time studies.

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MANATEES IN THE GULF OF MEXICO

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The endangered Florida manatee (*Trichechus manatus latirostris*) inhabits rivers and estuaries along both coasts of Florida and, to a lesser extent, adjacent states (Figure 1). Since 1990, documented sightings of manatees outside of Florida have been increasing. This increase in sightings probably represents northward shifts in manatee distribution made possible by man-made sources of warm water (i.e., industrial effluents), as well as a decade of relatively warm winters. The most likely source of emigrants on the Gulf coast is the population of manatees that overwinter in the headwaters of the Crystal and Homosassa Rivers, Citrus County, FL. This group of manatees has undergone a steady increase in numbers, (approximately 7% per year from 1977-1991; Eberhardt and O'Shea 1995). Some emigrants may also come from the Tampa-Ft. Myers region, where human impacts on habitat are greater. Manatees are intelligent, long-lived mammals that appear to adapt readily to new environments and situations. However, manatees have relatively low metabolic rates, and cold winter temperatures restrict their northern distribution.

RESEARCH

Research on manatees has increased dramatically over the last two decades. Research is conducted by federal, state and local governments, as well as several oceanaria and academic institutions. The Sirenia Project is a team of U.S. Geological Survey biologists that conducts long-term, detailed studies on the life history, population dynamics, and ecological requirements of the West Indian manatee (*Trichechus manatus*). Two federal laws (the Marine Mammal Protection Act of 1972 and the Endangered Species Act of 1973) and a state law (the Manatee Sanctuary Act of 1978) protect the manatee. The Florida Manatee Recovery Plan, prepared by an interagency team under the direction of the U.S. Fish and Wildlife Service, guides manatee research and management activities. Sirenia Project personnel serve as representatives on the Manatee Recovery Team. Project personnel also are active members in several working groups established by the Recovery Plan to coordinate research and management objectives for assessment of manatee population status, development of GIS applications, and evaluation of captive manatee releases.

The Sirenia Project has pioneered several important tools for manatee research, most notably development of a computerized photo-identification catalog, a radio tag assembly for tracking manatees by satellite in fresh or salt water, food habits and age determination techniques, assessment of manatee grazing impacts on seagrasses, survival estimation methods, and integration of life history data and population modeling. Project personnel also have been involved in developing and testing aerial survey techniques for manatees. Current research projects include (1) continued improvement of the photo-identification system and its application to estimation of manatee survival and reproductive parameters; (2) documentation of databases and protocols to meet metadata standards for biological data; (3) analysis of radio tracking data to determine patterns of movement and habitat use; (4) evaluation of releases of captive-born and captive-reared manatees; (5) seagrass ecology and manatee diet in selected high-use habitats; (6) radio tracking and habitat characterization in areas important to manatees in Puerto Rico; (7) genetic analysis and manatee population structure; (8) manatee use of thermal refugia and response to their elimination; and (9) international information and technology transfer.

STATUS ON THE WEST COAST OF FLORIDA

Most of the information on manatees has been gathered from long-term studies conducted in Florida; life history research in northwest Florida has been ongoing for over 30 years. Aerial survey data collected by the U. S. Fish and Wildlife Service demonstrate a steady increase in the usage of the thermal refugia located in the Crystal and Homosassa Rivers (Figure 2). The spring-fed winter refugia at the headwaters of these two rivers, and other smaller springs, offer thermal protection during cold weather. Abundant vegetation, fresh water flowing from the many rivers and creeks, and a relatively small human population along the northeastern Gulf of Mexico provide both winter and warm-season habitat for manatees. The probability of annual adult survival (96%) and reproduction (36% of adult females with first-year calves) are high enough in this region to maintain a growing population (Langtimm *et al.* 1998; Rathbun *et al.* 1995). Overall mortality and deaths caused by collisions with watercraft are relatively low.

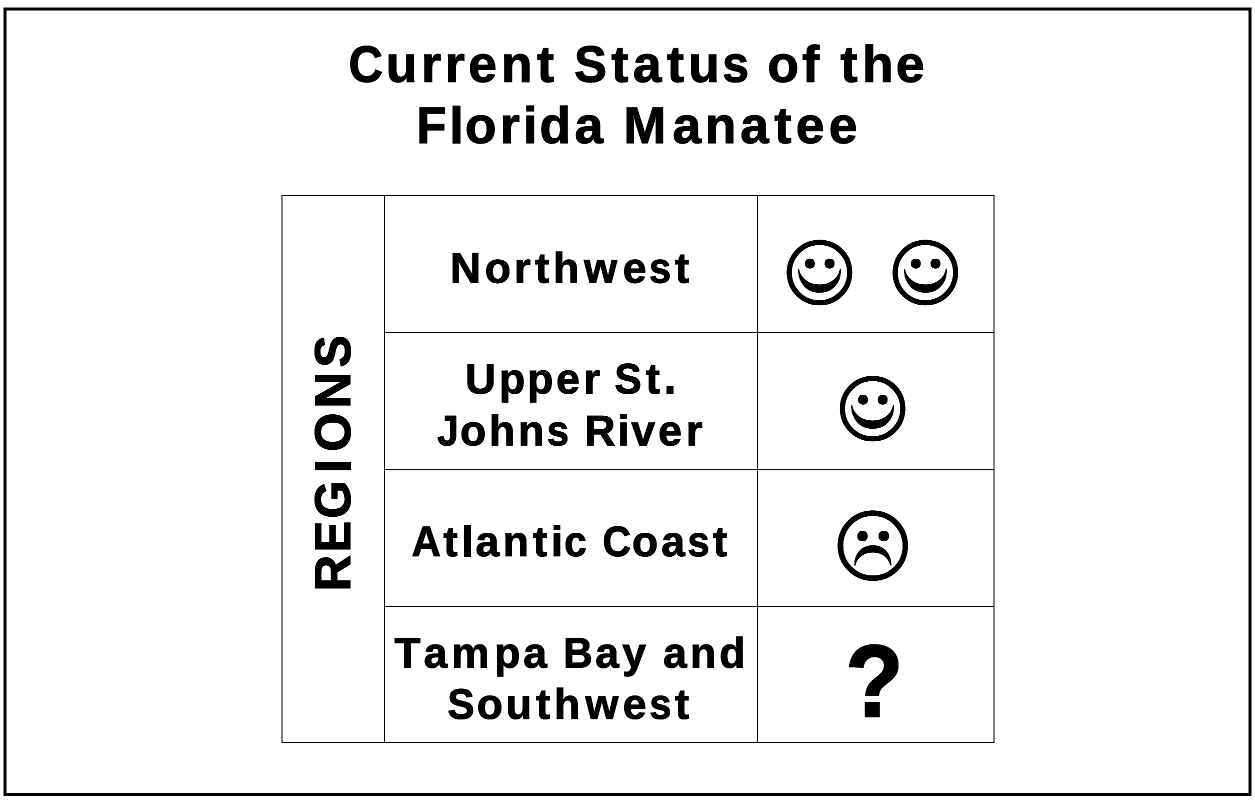

Figure 1. Current status of the Florida manatee.

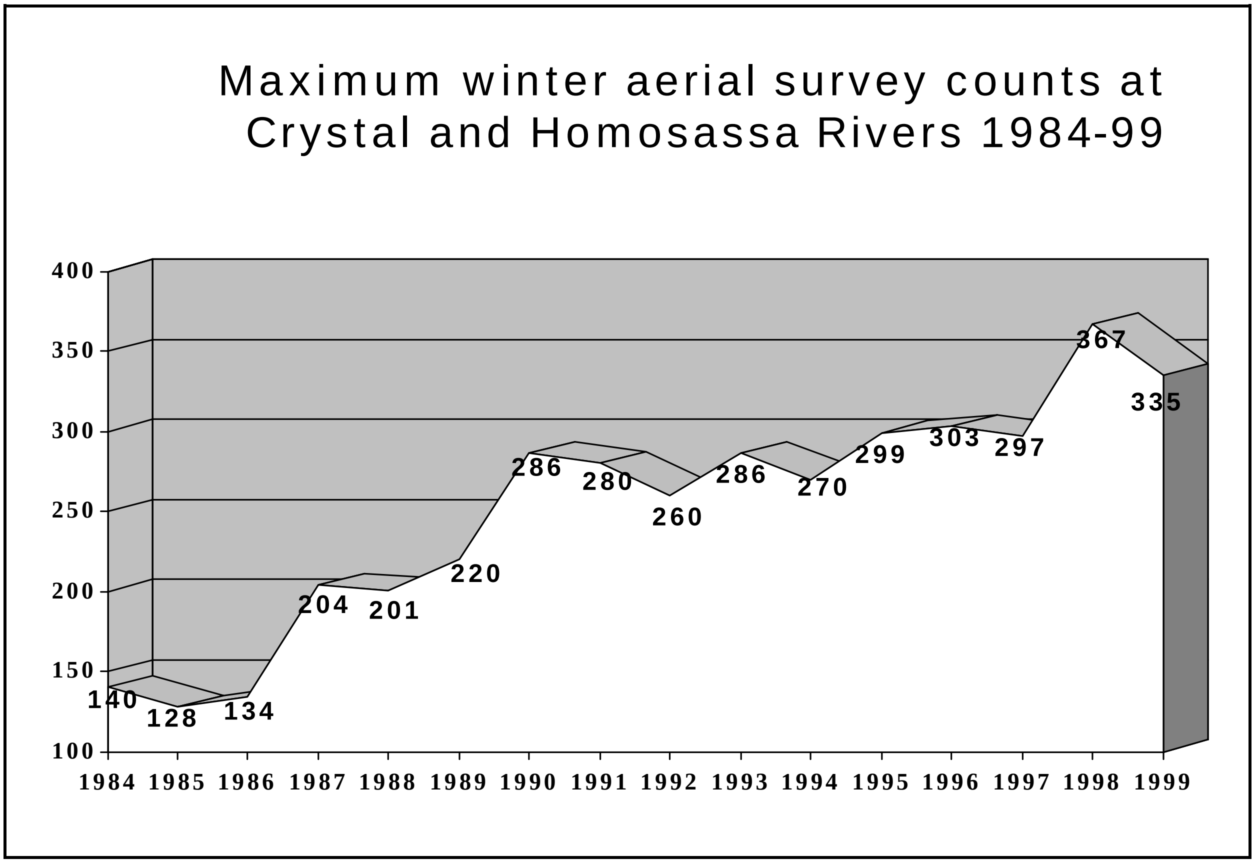

Figure 2. Maximum winter aerial survey counts at Crystal and Homosassa Rivers 1984-99.

Carcass salvage, telemetry, life history, and aerial survey data have been collected for the Tampa Bay-Ft. Myers region by researchers with the Florida Marine Research Institute- Department of Environmental Protection, Mote Marine Laboratory, and Eckerd College. Although survival and reproduction estimates are not yet available for this region, there is evidence of population growth in this region, particularly for the group that overwinters in Tampa Bay (B.B. Ackerman, Florida Marine Research Institute, pers. comm.). However, the number of manatee deaths is high in this region, particularly those caused by watercraft.

Very little is known about manatee status in the Ten Thousand Islands and Everglades National Park region of the Gulf Coast. Some aerial survey data (Everglades National Park and Florida Marine Research Institute) and radio tracking data (Florida Marine Research Institute and U.S. Geological Survey) have been collected.

THREATS

Deaths due to collisions with boats are the number one cause of human-related manatee mortality in the southeastern United States (Figure 3). As the human population in Florida increases, so does the number of human-related manatee deaths. The growth of the human population also has lead to

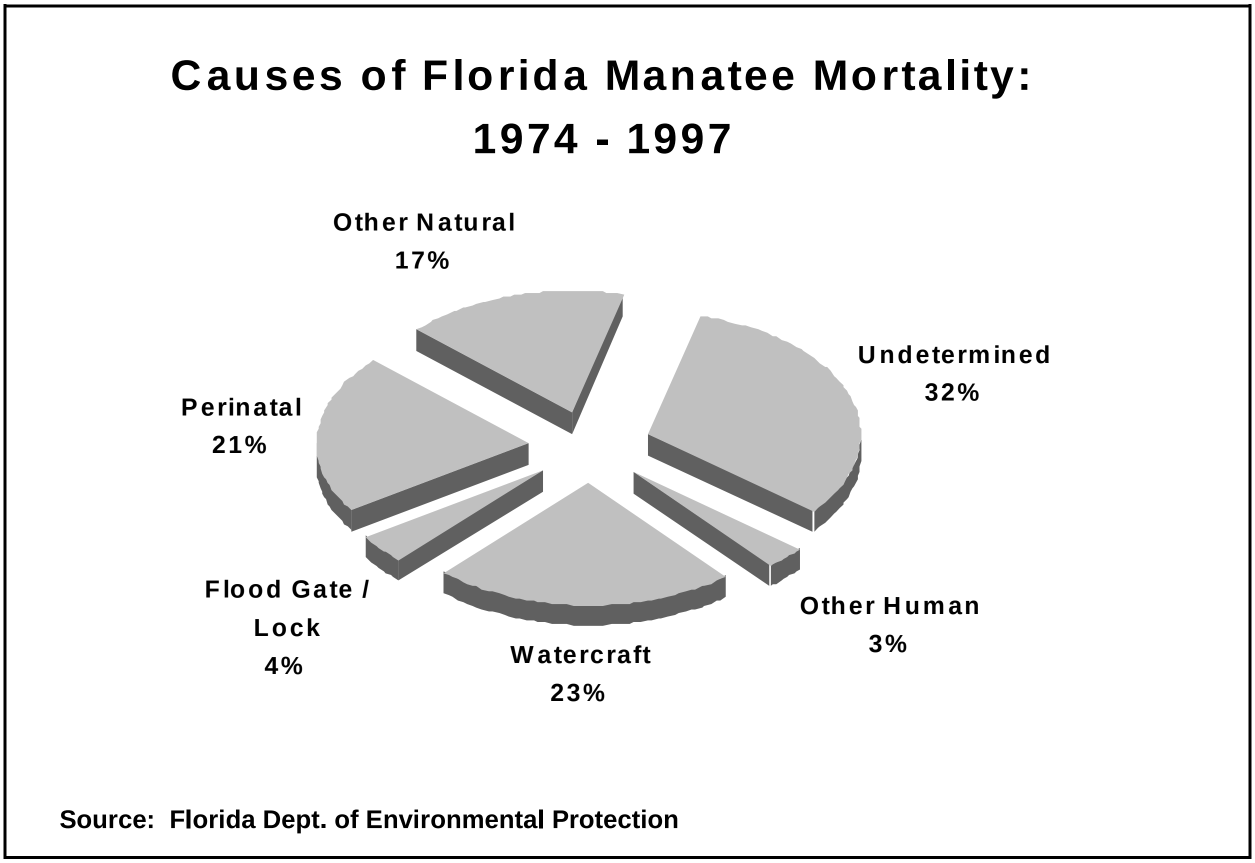

Figure 3. Causes of Florida Manatee Mortality: 1974-1997.

increased habitat degradation and perhaps has forced manatees to range beyond historic limits in search of suitable habitat.

Manatees are semi-tropical mammals that do not fare well in the cooler winter habitats of northern Florida and other Gulf states. Manatees need warm water during cold weather (ambient water temperatures < 18˚C), thus the region along the Gulf of Mexico to the west of Florida does not contain suitable winter habitat for manatees. Deregulation of the power-generating industry in Florida may result in erratic operation of power plants and could leave manatees "out in the cold" if they shut down during critically cold periods. This may limit the distribution of manatees into other Gulf Coast states.

In 1982 and 1996, toxic red tides (*Gymnodinium breve* blooms) caused significant manatee mortality in southwest Florida. Hurricanes and severe storms can impact manatee habitat by increasing salinity in inland waters, causing declines in the availability of freshwater vegetation upon which manatees feed. Conversely, large volumes of freshwater input to marine and estuarine manatee habitats can kill seagrasses, another important manatee food resource. Human impacts on water quality and quantity degrade manatee habitat. For example, there is evidence of reduced flow rates at some of the major springs used by manatees as thermal refugia. Human disturbance at major winter aggregation sites may affect manatee survival or reproduction, although no such impacts have yet been detected. Lack of genetic heterogeneity makes manatees more vulnerable to inevitable changes in the coastal environment.

RESEARCH NEEDS

1. Continue to collect basic life history information and expand data collection sites to include the panhandle and the Ten Thousand Islands (TTI) and Everglades National Park (ENP).

2. Analyze life history information to determine manatee population status for the entire Gulf Coast.

3. Collate existing aerial survey and telemetry data for TTI-ENP to develop a model that will predict manatee response to different South Florida ecosystem restoration scenarios.

4. Initiate radio tracking and other field studies in TTI-ENP that will provide data for the restoration model and population status determination.

5. Initiate radio tracking and other field studies that will provide data on warm-season manatee habitat use in the Big Bend and panhandle regions of Florida.

6. Continue genetic studies to determine manatee population structure.

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Bob Bonde has been a Biologist with the USGS Biological Resources Division, Sirenia Project for the past 20 years. He has 25 years’ experience with necropsy, 13 years’ experience with radio tracking, and 15 years’ experience with field observation and life history studies. He has flown over 38,000 miles of manatee aerial surveys in Florida and has done manatee and dolphin distribution surveys in Puerto Rico, Panama, Mexico, and Belize. He has captured, radio tagged, and tracked manatees in Florida, Puerto Rico, Mexico, and Belize using conventional VHF, satellite-monitored UHF, and sonic techniques.

Lynn W. Lefebvre is a wildlife biologist with the U.S. Geological Survey's Biological Resources Division at the Florida Caribbean Science Center in Gainesville, FL. She began working with manatees in 1985 and has been the Sirenia Project Leader since 1992. Her research interests include manatee feeding ecology, releases of long-term captive and captive-born manatees, and assessment of anthropogenic impacts on manatee populations. Lynn received her B.A.A.S. degree in biology at the University of Delaware, M.S. in wildlife management from the University of Massachusetts, and Ph.D. in zoology at the University of Florida.

SEA TURTLES OF THE GULF OF MEXICO

Dr. Maurice L. Renaud
National Marine Fisheries Service

Information presented below, on sea turtle biology, is not intended, nor professed to be complete or definitive. Its purpose is to serve as a cursory overview of selected aspects of sea turtle biology in the Gulf of Mexico.

Five species of endangered or threatened sea turtles, afforded protection in U. S. waters under the Endangered Species Act of 1973, inhabit the Gulf of Mexico. These are the Kemp's ridley (*Lepidochelys kempii*), loggerhead (*Caretta caretta*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*) and leatherback (*Dermochelys coriacea*). These animals are free swimming for almost all of their life but do occur on land as live or dead stranded animals, as nesting females and as hatchlings scurrying to the sea from their nests. Once offshore hatchlings become pelagic drifters. The length of the pelagic stage for Kemp's ridleys is estimated at 1-2 years, and 10-12 years for loggerheads. Information on early pelagic stages is not known for green, hawksbill and leatherback sea turtles. However, since leatherbacks reach sexual maturity around the same time as Kemp's ridleys (10 years), they may also have a relatively short pelagic phase.

Kemp's ridleys, loggerheads and leatherbacks are found along the entire Gulf coast (Figure 4). Kemp's ridleys, the shallowest of the three species, usually remain within 50-m depths, loggerheads extend into deeper waters near reefs and platforms, and leatherbacks occur out to 2,000-m depths. Green and hawksbill turtles occur off southwest Florida, Texas and Mexico (Figure 4).

Major nesting areas (>100 nests per season) of sea turtles in Gulf of Mexico are found at Rancho Nuevo, Tamaulipas, Mexico for Kemp's ridleys, along the southern and southwestern coasts of Florida for loggerheads, and on the northern Yucatan Peninsula, Mexico for hawksbills (Figure 5). Leatherback and green sea turtles have no major nesting sites in the Gulf of Mexico. All species of sea turtles in the Gulf of Mexico nest to a lesser extent throughout the Gulf coast (Table 4).

Many factors may influence sea turtle distributions in the Gulf of Mexico. Seasonal changes in water temperature are well correlated with the presence and absence of sea turtles. Turtles are found along the U.S. Gulf coast beginning in the spring (April and May) and remain there through the fall (Sept-October). Depending on how soon spring waters warm up and how long they remain warm in the fall, turtles may arrive in coastal areas as soon as February or March and remain as late as December (Landry *et al.* 1993, 1994, 1995). In fact, during mild winters with minimal or no freezing events, green turtles in south Texas have been known to overwinter (Arms 1996). Little is known concerning the whereabouts of sea turtles after they depart nearshore areas in the fall. In the absence of data, it was suggested that turtles leave areas in the winter to get away from cold water and seek out warmer environments. With the advent of satellite tracking technology, data are beginning to be compiled which support the above hypothesis. Sea turtles tracked during the winter do move offshore or toward more southerly latitudes where water temperatures are usually >17^{o}C. Seasonal

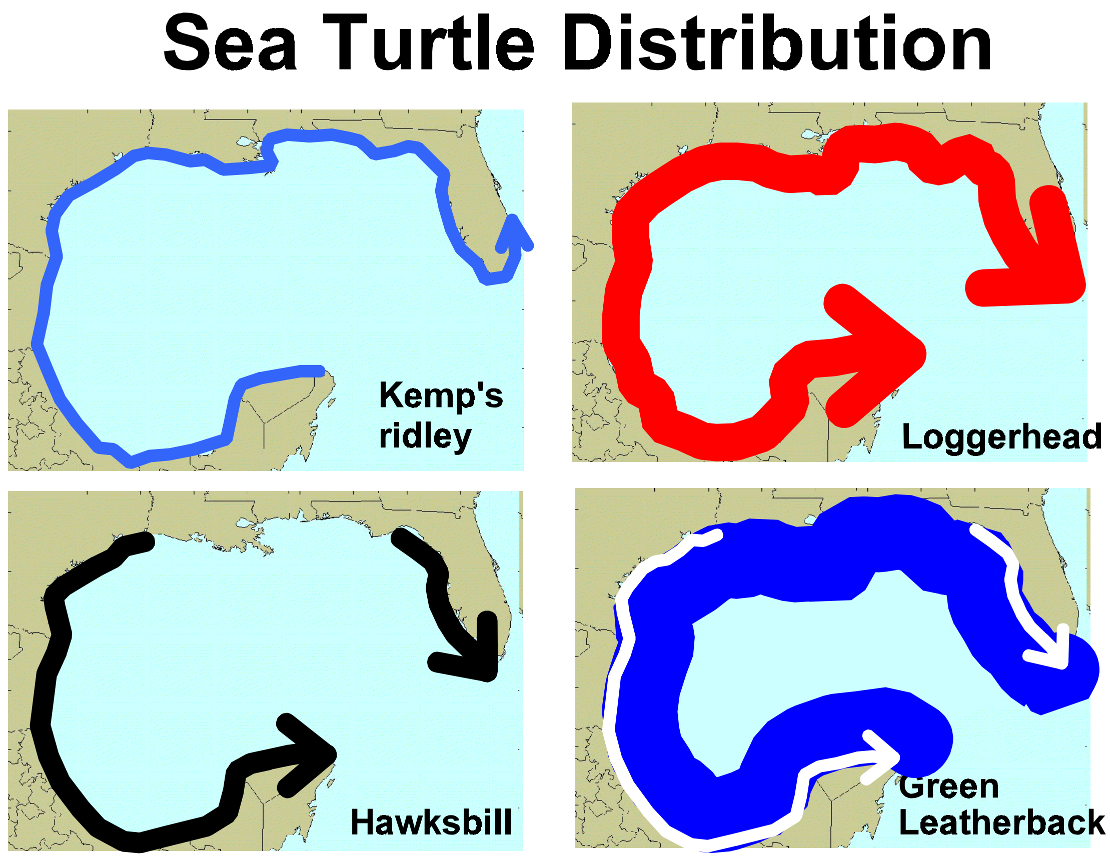

Figure 4. Sea turtle distributions in the Gulf of Mexico.

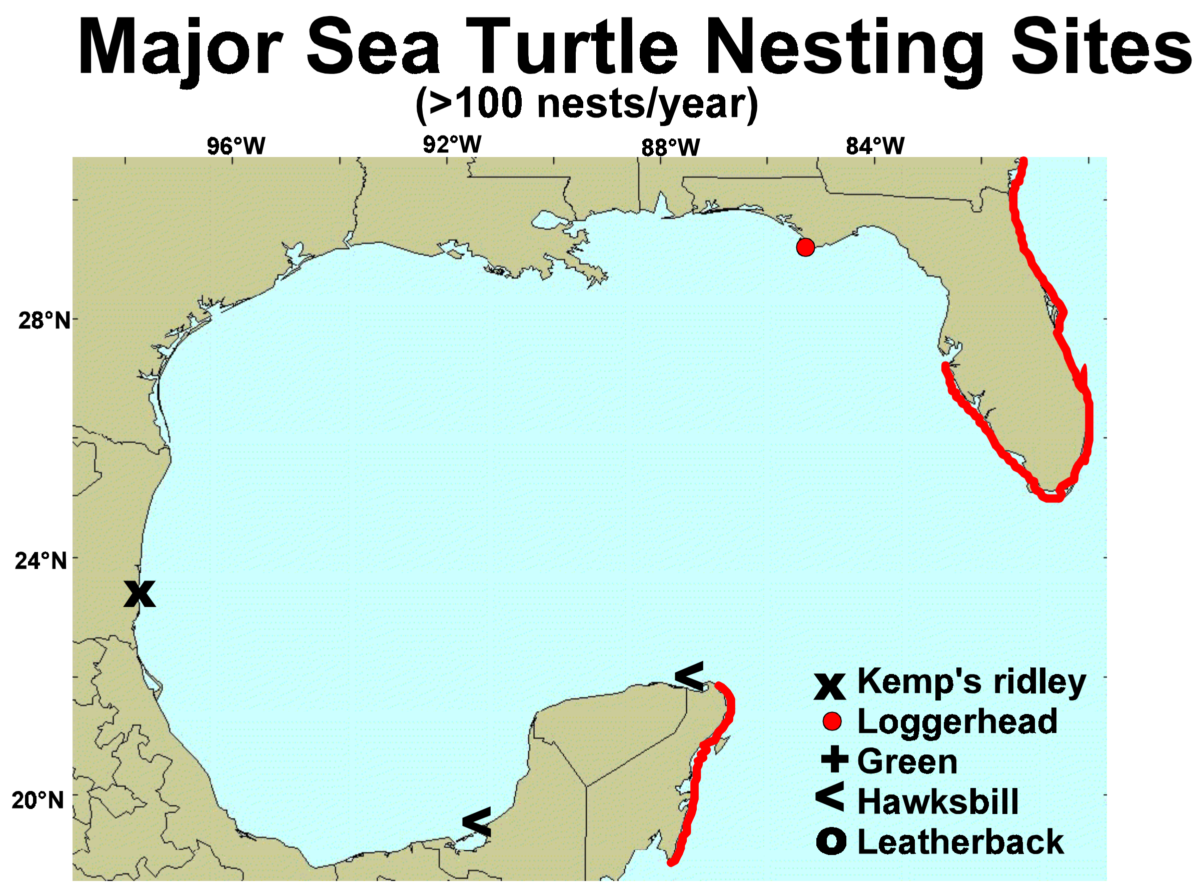

Figure 5. Major sea turtle nesting sites (>100 nests/year).

Table 4. Minor/Historical Nesting Sites of Sea Turtles in the Gulf of Mexico (<100 nests/ year).

	Kemp's Ridley	Loggerhead	Green	Hawksbill	Leatherback
Florida (Gulf)	X	X	X	X	X
Alabama		X			
Mississippi		X			
Louisiana		X			
Texas	X	X		X	
Tamaulipas	X	X	X		X
Veracruz	X	X	X	X	X
Tabasco	X	X	X	X	
Campeche	X	X	X	X	
Yucatan		X	X	X	X

migrations typically begin following the passing of cold front (Renaud and Carpenter 1994; Renaud 1995; Renaud *et al.* 1996). The stimulus to migrate may be a combination of the reduction of air and water temperature.

Other important factors that influence the movements and migrations of sea turtles are the urge to nest, the need to forage, and ocean depth. Although a gross over simplification, it can be said that sea turtles migrate to their nesting sites as a result of changes in their levels of reproductive hormones. Turtles do not nest every year, but when hormones elicit the production of egg follicles and egg development, turtles migrate to their nesting site while other turtles with insufficient levels of reproductive hormones remain in foraging areas. Sea turtles are mostly bottom feeders. Thus their distribution is limited to areas where they can dive to the sea floor to feed, as well as, to areas where their food sources occur. A high incidence of juvenile sea turtle foraging occurs along certain coastal regions of the Gulf coast. Prime examples of known nursery areas for sea turtles in the Gulf of Mexico are the Texas Laguna Madre, extending from the Texas-Mexico border to Mansfield Pass, Texas for green turtles, Sea Rim State Park, Texas to Mermentau Pass, Louisiana and Cedar Keys, Florida for Kemp's ridleys.

Although sea turtles in the Gulf of Mexico are sympatric to some extent, each fits into a definite niche. Habitat and food sources of these turtles are summarized below.

a. Kemp's ridleys – nearshore, shallow water mostly <50 m (crabs, fish, barnacles and gastropods)
b. loggerheads – geographic overlap with ridley, but extend out to depths approaching 2,000 m; occur near reefs and fixed structures in Gulf; omnivorous (crabs, sponge, jellyfish, barnacles, gastropods, urchins, sea pens, grasses and seaweeds)
c. leatherback – juveniles occasionally shallow, but species occurs mostly in 100-2,000 meter depths; omnivorous (tunicates, urchins, jellyfish, squid, fish, algae)

d. greens – occur on shallow reefs, shoals and lagoons; mainly herbivorous (marine grass and algae), limited carnivory in juveniles
e. hawksbills – inhabit shallow water reefs and lagoons; omnivorous (sponges urchins, barnacles, sea grass, algae, coral)

In the northern Gulf of Mexico, tracking studies have shown that Kemp's ridley, loggerhead and green sea turtles spend 90-95% of their time under water. Although individual submergence variation occurs, there do not appear to be differences by species, turtle size or season of year (Renaud and Carpenter 1994; Renaud 1995; Renaud *et al.* 1996). These values are similar to those for adult green turtles in the Pacific (96%, Balazs 1994), adult post-nesting Kemp's ridleys off Mexico (96%, Byles 1989), juvenile loggerheads in near Cape Canaveral, Florida (96%, Kemmerer *et al.* 1983) and Olive ridleys in the Pacific (88%, Byles and Plotkin 1994). Dive duration, on the other hand, varies by species, size of turtle and season. In general, the larger the Kemp's ridley, loggerhead or green sea turtle, the longer it is capable of remaining submerged. Winter submergences are significantly longer than submergences for other seasons. Submergence data are not available for hawksbill or leatherback turtles in the Gulf of Mexico. Mean dive times may be less than 15 minutes in the summer to over an hour in the winter.

We are encouraged about information gathered on sea turtles during the past 10 years. However, though our knowledge has increased tremendously, we are not near a complete understanding of sea turtle biology and ecology. Turtles are long-lived animals and our data cover only a minute segment of their life span. Thus, we shouldn't let our advances cloud the facts: our sample size is small, and work needs to continue on all species of sea turtle in the Gulf of Mexico.

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Maurice Renaud, an ecologist, began working in Galveston, TX with the National Marine Fisheries Service in 1980. During his tenure at NMFS, his scope of work has included topics such as shrimp migrations, hypoxia in the Gulf of Mexico, the effect of trawling efficiency devices (TEDs) on commercial shrimp catch, and since 1986, the behavior and migration of sea turtles, and characterization of sea turtle habitat in the Gulf of Mexico and Atlantic Ocean. Maurice received his B.A. in Zoology (1970) and M.S. in zoology (1971) from the University of Hawaii and his Ph.D. in zoology (1977) from Arizona State University.

INDUSTRY: MAN-MADE AND NATURAL ACTIVITY IMPACTS ON MARINE MAMMALS AND SEA TURTLES

MMS AND DEEPWATER ACTIVITIES

Mr. Jim Regg
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Deepwater drilling activity is at an all-time high, and production from deepwater reservoirs is also increasing. Minerals Management Service (MMS) statistics indicate that the number of rigs concurrently operating in water depths greater than 1,000 feet has averaged 16 during late 1995 and early 1996. In several instances the deepwater rig count has increased to levels approaching 20 rigs. The continued growth of the deepwater Gulf of Mexico (GOM), especially the ultra-deep blocks, might be constrained by the availability of drilling vessels capable of operating in those water depths. Numerous trade journals have published articles about the successes of GOM deepwater projects, lists of projects under development or pending, and water depth records for deepwater drilling, mooring, and installations. The important point is that the GOM offshore has seen a much-needed revitalization with the excitement of deepwater drilling and production. It is in everyone's best interest that the successes continue.

There are probably as many answers to the question "How deep is deepwater?" as there are responses. From an operations perspective, the MMS considers deepwater with respect to regulating production activities as beginning where industry uses different technology to develop and produce oil and gas from the Outer Continental Shelf. In the Gulf of Mexico, this shift occurs where industry stops using fixed platforms and begins using other types of facilities to produce oil and gas from deeper waters, i.e., subsea facilities, floating production facilities, tension leg platforms, etc. The exact water depth of deepwater is not important; however, the change in production technology generally begins in water about 1,000 to 1,300 feet. The MMS adopted 1,000 feet as the marker for deepwater.

Existing MMS offshore operating regulations were promulgated based on an expansion of successful bay and inland estuary production activities. These regulations reflect mostly surface operations where daily access to the wellhead(s) is possible. In 1988, the MMS had consolidated a multiple layer of regulations, orders, and policies into the single document containing all then-existing regulations. This effort resulted in updating regulatory requirements with industry operating practices and standards and incorporating performance-oriented requirements into the regulatory structure. Those regulations continued the focus on surface-based operations; the 1988 revision did not address in specific terms the requirement for subsea production systems and several other particulars associated with deepwater operations. Because of this lack of specific regulations and different functional requirements for deepwater and subsea activities, the MMS has been granting approvals for alternative compliance measures as departures from the existing regulations when the alternative means provide an equal or greater level of safety when compared to the existing requirements. Both the MMS and industry have concerns about the use of departures for regulating offshore operations, especially in the dynamic deepwater arena where economic and technical concerns can have a dramatic effect on the viability of a project. A proactive approach to addressing the MMS and industry concerns was needed.

In response to this need, MMS formed a work group to examine regulatory issues associated with deepwater operations and development. The primary functions of the work group were to (1) review the current offshore operating regulations for applicability to deepwater and subsea operations and (2) recommend measures to improve the deepwater regulatory program. This internal MMS Deepwater Production Work Group began its regulatory analysis in early 1992 by investigating options regarding regulations for floating and subsea production systems. One goal of the work group was to develop a report that would address the needs of the current regulatory program with respect to deepwater. Early in the review process, the work group prepared case studies of several deepwater projects to obtain an accurate picture of how MMS regulates deepwater activities. The work group examined previously raised issues regarding floating production and deepwater activities. These issues included the approval and use of floating production systems and tension leg platforms, deepwater pipeline design, gas flaring, extended well testing, and subsea production and safety system requirements.

A review of deepwater projects revealed that MMS had no major problems in the review and approval of past deepwater projects. However, the case studies revealed that MMS had to grant departures to the regulations in the approval of each project. The case studies also indicated that the review process by MMS was not always consistent. The MMS granted some departures because the technology used did not fall within the parameters of the current regulatory requirements. For example, industry was not able to monitor the annulus pressures in all casing strings in sub sea wells because of the design of subsea wellheads. The MMS granted other departures for underwater and subsurface safety valves because the current regulations do not adequately address this equipment when it is used in deepwater and subsea operations.

A primary example of MMS and industry proactive cooperation is the new approach for reviewing deepwater development activities, referred to as the Deepwater Operations Plan. Through the DeepStar Regulatory Issues Committee, MMS and industry participants were able to jointly evolve the Deepwater Operations Plan concept for subsea development. DeepStar took the lead to develop a working model of the plan using a known and previously approved GOM subsea development project as a guide. Periodic meetings of the Regulatory Issues Committee provided the opportunity for industry and MMS feedback as milestones were achieved in the working model development. The Deepwater Operations Plan evolved, formal comments were solicited and alternative versions of the guidelines were considered. The cooperation and open dialogue from both the industry and MMS were key to the formulation of guidelines to be used for subsea deepwater operations plans. The MMS has adopted these guidelines and announced the implementation of the Deepwater Operations Plan requirement by a Letter to Lessees and Operators. Before finalizing the guidelines, the Gulf of Mexico Offshore Operators Committee, Independent Petroleum Association of America, and DeepStar member companies were provided a final opportunity to comment on the document and implementing Letter to Lessees and Operators.

The guidelines for implementing the Deepwater Operations Plan identify specific needs concerning the areas noted above. An important point to recognize is that the plan is not intended to duplicate other submittals required by the MMS; anything that has received prior approval or that is pending can simply be cross referenced in the Plan.

The MMS and industry benefit from the Deepwater Operations Plan through the early interaction and dialogue regarding the proposed development strategy. The plan is submitted to the MMS in three parts: conceptual, preliminary, and final. Each part reflects the operator's state of knowledge regarding the project and provides an early opportunity for the operator and MMS to agree on the proposed development strategy (design basis and philosophy) prior to major expenditures. The conceptual part addresses innovative and unusual technologies essential for the viability of the project. The preliminary part identifies the alternative compliance measures to be used along with the description of the overall system configuration. Updates to the previous submittals are the main focus for the final part. This three-part submittal approach for a Deepwater Operation Plan is intended to reduce the overall risk of the project.

The MMS and DeepStar have cooperated since 1992 to facilitate the development of deepwater discoveries in an environmentally and safety-conscious manner. The purpose of this cooperative effort has been to move both industry and regulators toward a common goal of mitigating all barriers to deepwater development. The approach has been to identify issues and concerns to be fully discussed before actions are formulated. Through the interaction and substantial contributions from industry through DeepStar, MMS has been able to adopt a total-systems approach to reviewing deepwater development activities. This new approach, referred to as the Deepwater Operations Plan, provides for using alternative compliance measures where justified, rather than obtaining departures from regulations and policies based on fixed-leg platform type operations. The approach also avoids, at least in the near term, the development of safety regulations that would require frequent revisions because of evolutionary deepwater technology. The Deepwater Operations Plan approach provides an early regulatory review prior to full-scale development, a measure that should reduce some of the risk associated with deepwater development planning.

The approach adopted by MMS and DeepStar has potential application in other areas as well. The co-sponsoring of informational workshops and scoping initiatives, safety and technology research, and the early involvement in regulatory initiatives will benefit both industry and the MMS.

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OFFSHORE PRODUCTION OPERATIONS: AN OVERVIEW OF GULF OF MEXICO OCS OIL AND GAS OPERATIONS

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Domestic U.S. offshore oil and gas industries operate with the permission of the public and under the regulatory supervision of a number of state and/or federal agencies. In general, the U.S. Minerals Management Service oversees leasing, royalty payments, exploration and production planning, facilities, operations, pipelines, abandonment, environmental impact mitigation, and coordination with other agencies. EPA regulates discharges into Gulf of Mexico waters and, in the eastern Gulf, air emissions. The Coast Guard governs life-saving systems, emergency evacuation plans, fire fighting systems, and oil spill responses. NOAA, NMFS, DOE's RSPA and the Army Corps of Engineers oversee various other OCS activities. In all, OCS oil and gas activities are among the most tightly regulated in the world. The remainder of this paper describes what kinds of facilities and operations those are.

The earliest OCS facilities, dating back to the 1930's, were relatively simple structures framed of timbers. Within a decade, however, steel structures began displacing wooden ones and allowing the industry to work in deeper waters. Today, approximately fifty years after OCS exploration and production began, water depths approaching 10,000 ft. are being explored.

With this extension into deeper waters have come new technologies for drilling and producing new discoveries. A new generation of drilling ships, for example, is under construction. Wells are being completed on the seabed and piped back to existing infrastructure for processing. Various kinds of floating and tension-moored structures are producing in waters so deep that they render conventional pile-supported structures impractical. Among the most innovative of these structures is Chevron's Genesis spar – a huge, floating buoy-like hull supporting multiple decks of production equipment and marine systems. Genesis is unique in its capability to simultaneously produce oil and gas while drilling new wells (or "working over" existing wells). It operates in 2,600 ft. of water in Green Canyon Block 205, about one hundred miles south of Grand Isle, Louisiana.

Another technological development has been the industry's ability to complete wells at the seabed, eliminating the need for surface structures entirely. In this kind of development, all of the controls needed to operate the wells are placed on the seabed and operated remotely via an umbilical bundle. Oil and gas flows through a blowout preventer atop each well to a nearby production manifold. There, the production is combined and exported to a conventional production facility via subsea pipeline. An example of this development is the Gemini production system in Mississippi Canyon. Texaco operates the subsea system, located in 3,745 feet of water. Production from Gemini is tied back to partner Chevron's facility in Viosca Knoll Block 900 for processing and transport to shore.

Most of the "major" structures, or platforms, on the OCS house various numbers of wells and the production equipment used to separate oil, water and gas; generate power; pump oil and gas to shore; and provide living quarters for the crews. In older, shallower fields there are often a number of smaller satellite structures which may be as simple as a caisson for a single well and a small "flowline" to transport its production back to a processing platform. Of course there is also a continuum of structures intermediate in size between "major" and single well structures. Typically, these intermediate facilities house multiple wells and various combinations of processing and separation equipment.

The central and western OCS in the Gulf of Mexico is home to thousands of oil and gas production structures. During the operational lives of these facilities, submerged structural members become thickly encrusted with algae, sponges, corals and other organisms. In a very real sense they become artificial reefs. Those communities in turn attract free swimming grazers and predators, including many species more typical of natural coraline reefs of lower latitudes than of the soft, sedimentary basin which characterizes most of the Gulf of Mexico.

The topsides of these facilities also serve as an archipelago of rest stops for birds and insects migrating between North and Central America via the Gulf. Sea turtles, whales, dolphins and porpoises are frequently found in the vicinities of platforms, though they probably do not utilize them for feeding or shelter.

After OCS facilities become surplus they must be removed in accordance with U.S. and international law. In recognition of the fisheries habitat they provide, however, most of the Gulf states encourage operators to donate surplus structures to permitted artificial reef sites. These states' artificial reefs programs assure continued benefits to fisheries otherwise limited by absence of naturally-occurring "hard-bottom" reef substrate.

ACOUSTIC ACTIVITIES OF THE SEISMIC INDUSTRY

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INTRODUCTION

This paper provides a brief overview of some of the continued improvements and recent advances in the acquisition and use of 3D seismic data. Length constrains the topics to be covered in this talk to (1) a brief review of the seismic equipment used in 3D seismic surveys today, and the recognition that more and more in-sea equipment is being towed behind purpose-built and purpose-modified seismic vessels, (2) some technical tidbits about airgun arrays, and (3) recent developments in seismic seabed equipment used in repeat 3D seismic surveys (popularly known as 4D seismic), and in marine multicomponent seismology (marine 4C).

EQUIPMENT LAYOUT IN 3D SEISMIC SURVEYS TODAY

Improvements in vessel technology as well as in towing systems, recording systems, safety systems, etc., ensure that the seismic industry will continue to increase the amount of in-sea equipment for the acquisition of 3D seismic surveys (Figure 6). Spreads of up to 1,500 meters (the total separation

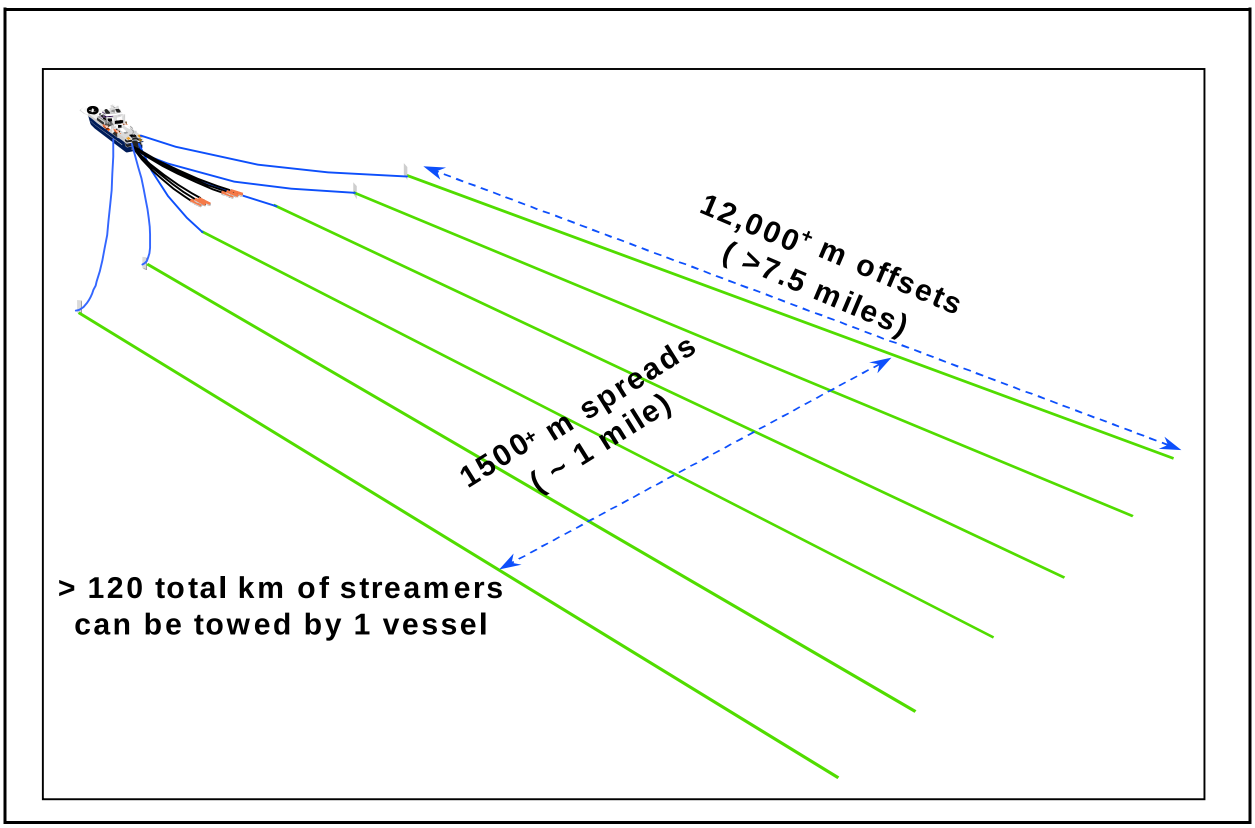


Figure 6. The seismic industry will continue to increase the amount of in-sea equipment for the acquisition of 3D seismic surveys.

Figure 7. A streamer cable rolled up on a drum.

from the leftmost streamer to the rightmost streamer) and more, and streamer lengths of up to 12 km will be seen in 1999. Some contractors can achieve these maximum geometries with a single vessel; others will need as many as three or four vessels to attain this geometry. The sea area covered by the length of the streamers multiplied by the spread of the full set of streamers defines the acquisition footprint. The acquisition footprint, on average, associated with a single traverse of a seismic vessel will increase in area over the next couple of years, and open water tracts (such as the deepwater in the Gulf of Mexico) provide areas where operations using these maximum geometries are most cost-effective.

Figure 7 shows a streamer cable rolled up on a drum, or reel, where the reel has a diameter of about 12 feet. The diameter of the streamer is slightly larger than 2 inches. The yellow cylinders seen inside the streamers are spacers that maintain the streamer's shape and keep the internal electrical wires and sensor units in their correct positions.

Figure 8 illustrates how a seismic survey is actually shot. If the desired geometry of the ship's tracks is indicated on the left side of the diagram, then the vessel towing its airguns and streamers will actually shoot the area Zamboni-style, as indicated on the right half of the diagram. It must be kept in mind that the colored arrows in the right half of the diagram denote a total system geometry of a vessel, its airgun array(s), and the long line(s) of streamers being towed behind it.

Towing longer streamers, more streamers, and a wider spread of streamers means that today's seismic vessels have to be more powerful than those of yesterday, which typically means more powerful engines and larger and/or more powerful propellers (screws). It might be thought that these more powerful systems would be noisier than the older ones, but R&D efforts have ensured, in fact, that today's systems are as quiet, if not quieter than earlier models. Therefore, the ultimate effects of increasing the size of the acquisition footprint are to (1) reduce the number of firings of an airgun array for a given 3D seismic survey, and (2) reduce the time it takes to shoot a given survey.

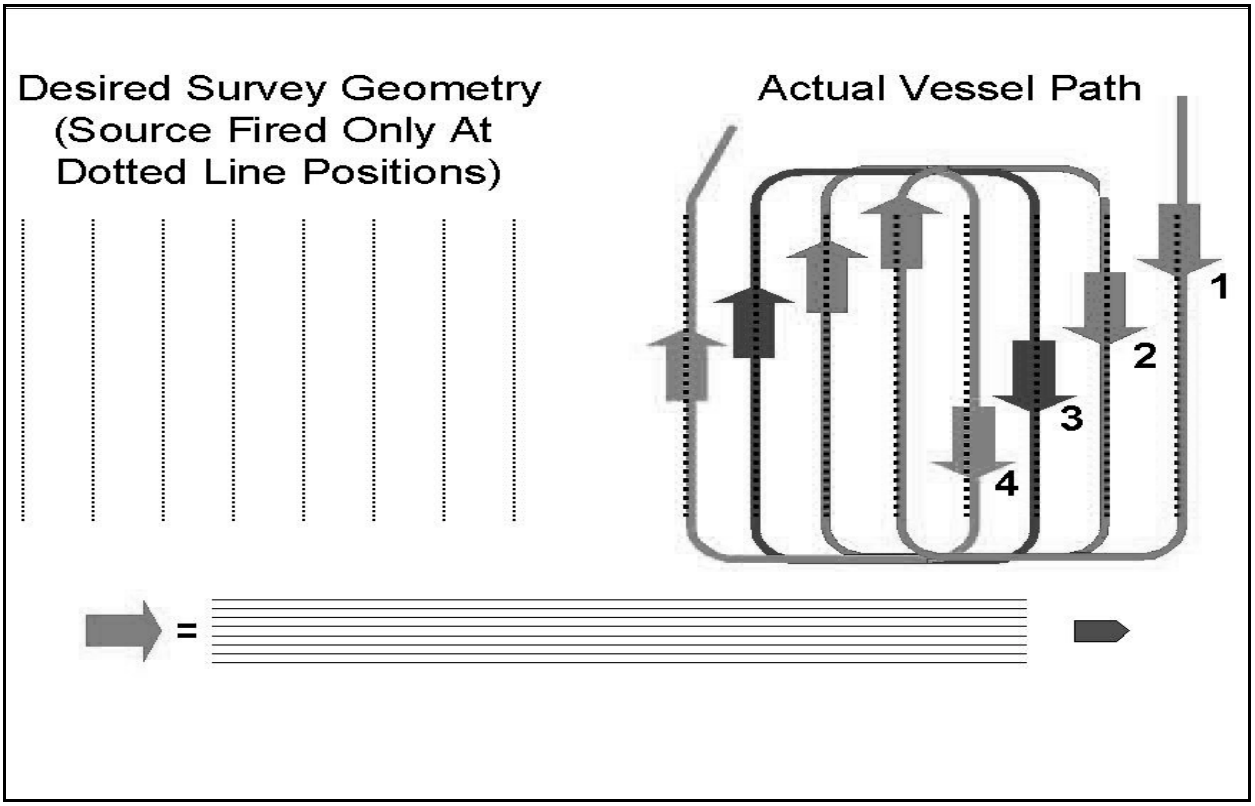


Figure 8. An illustration of how a seismic survey is shot.

TECHNICAL TIDBITS ABOUT AIRGUNS

Figure 9 shows a portion of an airgun array. Note the man kneeling for scale. Notice the floats that support the airguns (the orange tubes that look like large hot dogs) and the air guns themselves hanging beneath the floats. Typical volumes of air expelled by airguns vary from about 30 cubic inches up to about 800 cubic inches, and when one speaks of the volume of an airgun, or about the size of an airgun array, it is in terms of this volume (for a single gun), or the sum of the volumes of each gun (for the whole array). Total airgun array sizes cover a wide spectrum, but most of the industry's arrays will be between 3,000 and 8,000 cubic inches. An airgun array generally consists of three to six subarrays, with each subarray being a linear alignment of four to eight individual airguns. This means that each complete airgun array will typically involve 15 to 30 individual guns. Most of the seismic industry use airgun arrays whose operating pressure is 2,000 pounds per square inch.

Figure 10 shows a schematic diagram of a specific airgun array, one that is 3,959 cubic inches in total volume, has 3 subarrays (each line of ovals), uses 17 airguns (each individual oval represents an airgun, and the nearest number represents the volume of that gun in cubic inches), and measures 18 meters by 18.5 meters in size. The location of the airgun array is indicated in Figure 10 in the inset aerial photo of a seismic vessel. A key concept to note here is that an airgun array is definitely not a point source, but one that spans a small area. The specific design of an airgun array is based

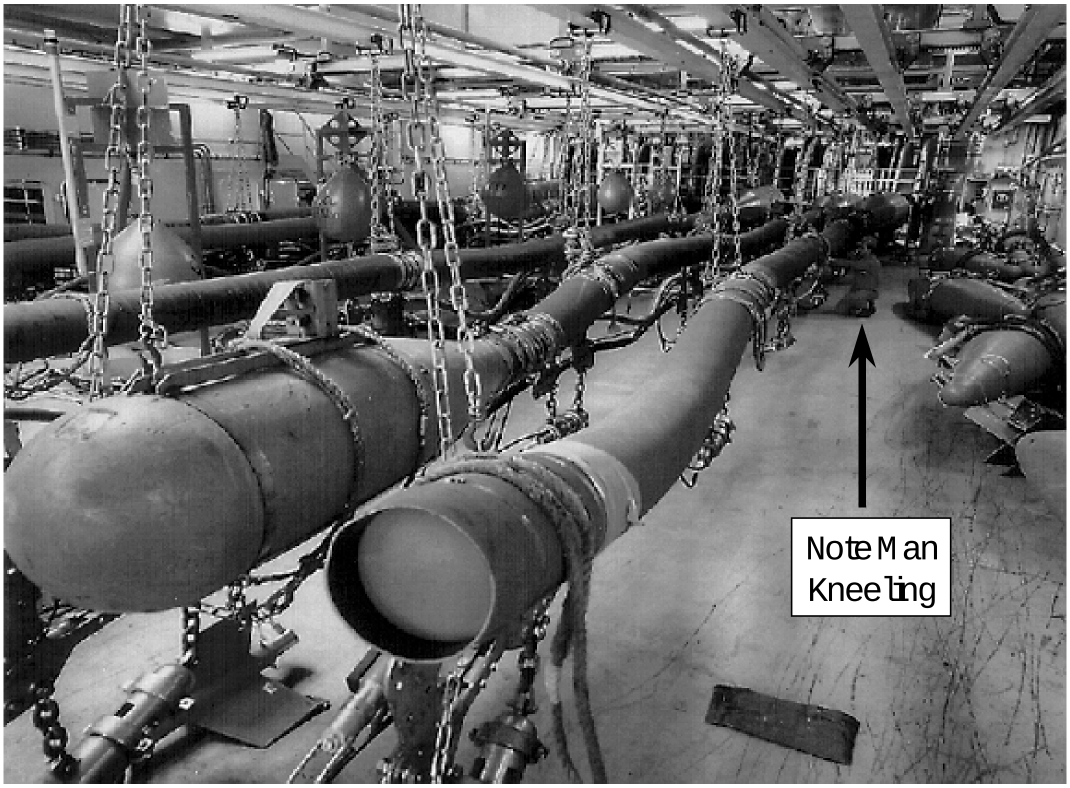


Figure 9. A portion of an airgun array. Note the man kneeling for scale.

on the desire to have a source that emits a very symmetric packet of energy in a very short amount of time, and with a frequency content that penetrates well into the earth in the particular geographic location in which the seismic work is being conducted. Those desires then dictate how many guns of what size form the total array, and dictate the exact location and firing pattern of the individual airguns. The firing times of the individual guns are staggered by milliseconds so as to make the far-field pulse emitted by the total array as coherent as possible. The choreographing of the firing times, and the ensuring of its proper execution, is known as tuning the airgun array.

The sound pressure (amplitude) generated by an airgun array is

(1) linearly proportional to the number of guns in the array: all else being equal, a 30-gun array will generate twice the amplitude of a 15-gun array;
(2) linearly proportional to the firing pressure of the array: typically the industry uses 2,000 psi, but a 4,000-psi-array will have twice the amplitude of a 2,000-psi-array;
(3) proportional to the cube root of the volume of the array: an 8,000-cubic-inch-array will generate twice the amplitude of a 1,000-cubic-inch-array.

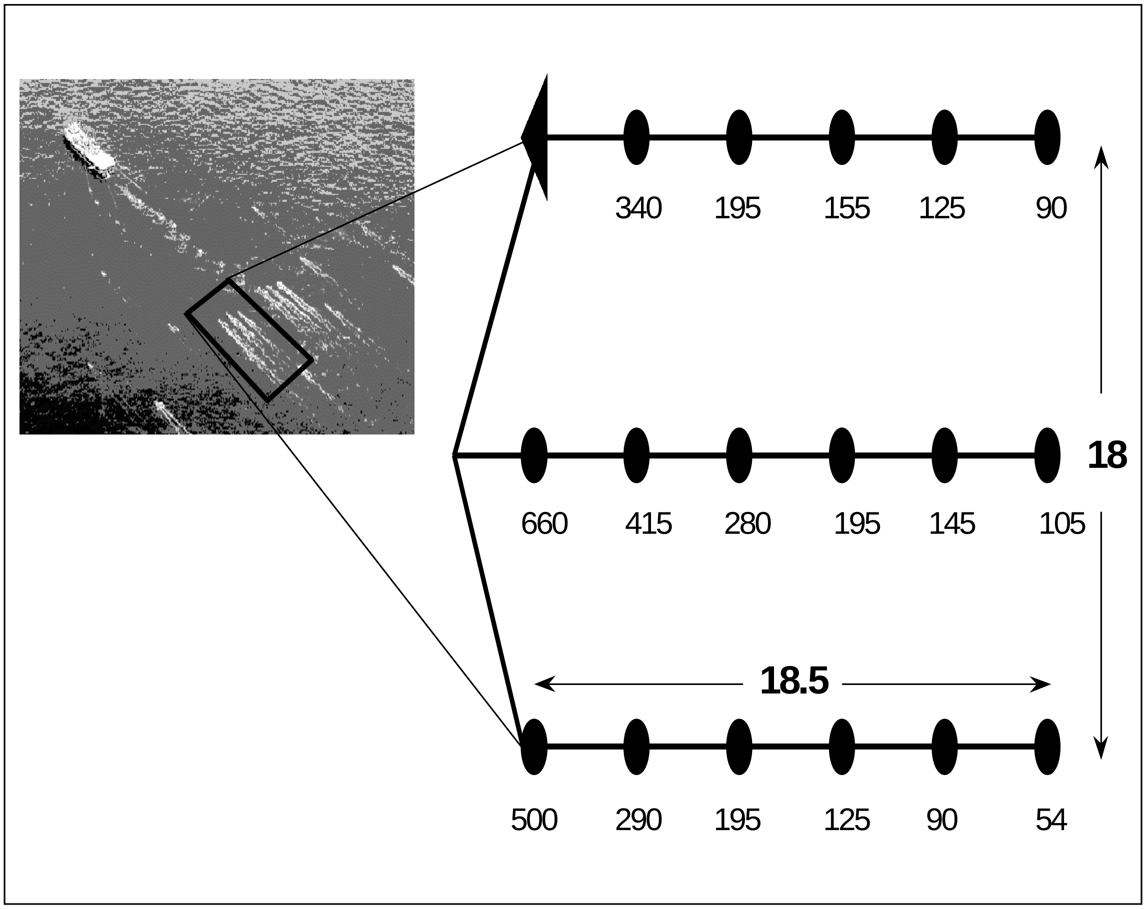


Figure 10. A schematic diagram of a specific airgun array, one that is 3,959 cubic inches in total volume, has 3 subarrays (each line of ovals), uses 17 airguns (each individual oval represents an airgun, and the nearest number represents the volume of that gun in cubic inches), and measures 18 meters by 18.5 meters in size.

The sound pressure level decreases rapidly as the distance from the source increases. At distances of about 500 meters and more (also known as the far-field), the individual airguns in airgun arrays will look as if they are all working as one source; they *constructively interfere* with one another, and the total array can then be considered a "point source." For distances less than that, and particularly within about four or five array dimensions, 125 meters or so (known as the near-field), the effect of numerous guns firing asynchronously is to cause destructive interference of the output of each individual gun.

If an airgun array were a point source, then one could make measurements a few hundred meters away from it, and mathematically back-calculate the level of the generated sound pressure at the exact location of that point source. For typical industry airgun arrays, that typical *back-calculated* *value would b e on the order of 100 bars*. Numbers of that magnitude are what the seismic industry publish to let its clients know *the effective output at great distances* of its array. Because the arrays used are not point sources, the mathematical back-calculations are not accurate at all in terms of the sound pressure actually encountered within 125 meters or so of the center of an array. Actual measured values verify that *the maximum real sound pressure experienced anywhere within the near-field is less than 10 bars*, or less than one-tenth the published values.

In typical industry practice, a hydrophone is placed one meter away from each airgun in an array, and it is used to measure the actual sound pressure generated at that point. (The industry uses these hydrophone data to monitor the performance of each airgun and to help in the computer processing of the data.) Figure 11 shows data recorded by these hydrophones for dual 3,397-cubic-inch arrays. Each of the two arrays consists of 24 guns, eight in each of three subarrays. Each array is 20 meters wide by 15 meters long. These data are from a survey acquired in May 1999.

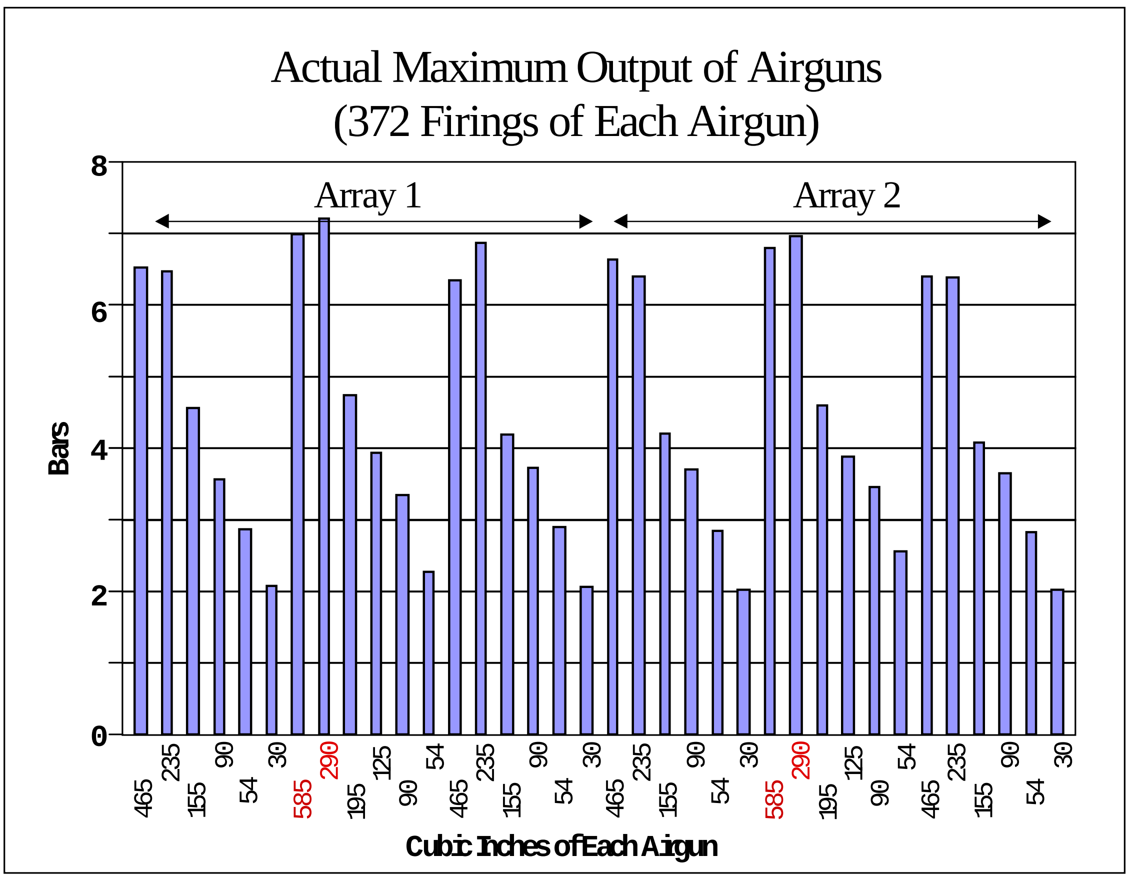


Figure 11. Data recorded by hydrophones for dual 3,397-cubic-inch arrays. Each of the two arrays consists of 24 guns, eight in each of three subarrays. Each array is 20 meters wide by 15 meters long. These data are from a survey acquired in May 1999.

Each bar in this graph represents the average maximum pressure (zero-to-peak) measured by each gun hydrophone (located 1 meter from the gun) for 372 firings of each gun. The number along the bottom of the plot indicates each gun size. Data from the first array is shown on the left half of the graph starting with the first "465" and ending with the second "30" annotation. Data from the second array is shown on the right half of the plot, beginning with the third "465" and continuing to the right. The maximum average value is 7.19 bars, and is generated by the 290 cubic-inch gun in the first array. The absolute maximum in this total data set, not discernable from this plot, but observed in the raw data before averaging, is 8.73 bars. Several observations:

(1) the two arrays look very similar in their outputs;
(2) the most energetic guns are not the largest guns;
(3) different guns of the same size have very similar outputs;
(4) the maximum output actually measured anywhere is less than 10 bar-meters.

In the actual recording of seismic data, the sound pressure of the first energy being recorded by the sensors in the streamers will typically be in the 40 to 60 millibar range. This is due to the relatively long distance traveled by the energy before reaching the nearest sensors (a few hundred meters typically). In good conditions, the ambient noise level, made up of in-streamer noise such as vibrations and bulge waves, as well as environmental noise like wind and waves, will be around 2-3 microbars.

Figure 12 shows the amplitude level for a typical seismic trace as a function of recording time (the heavy line). The amplitude decay for cylindrical spreading of a pressure pulse is indicated on this plot, and the decrease is proportional to one over the square root of the distance from the source. The amplitude decay for spherical spreading of a pressure pulse is also indicated on this graph, and the decay is proportional to one over the distance from the source. The plot indicates that most seismic traces will decay somewhere between the spherical spreading case and the cylindrical spreading case. (Exactly how the sound decays depends on the specifics of the survey area.) Also shown on this plot are various reference points:

(1) the back-calculated level of airgun arrays (the 260 dB ref 1 microPascal at 1 meter),
(2) the actual maximum level of airgun array output (the 220-230 dB level) corresponding to 5-10 bar meters (zero-to-peak) and 3-7 bar meters (RMS),
(3) the current level of caution indicated by mammal experts (180 dB), and
(4) the level of the click of a solenoid that initiates the firing of an airgun (160 dB).

MARINE MULTICOMPONENT (4C) SEISMOLOGY

The four-component (4C) seismic is another application that makes use of either sensor-filled cables or individual sensor packages placed in direct contact with the seafloor. The four components are a hydrophone (denoted by P in Figure 13), a vertical geophone (Z), and two horizontal geophones (X and Y) oriented perpendicular to each other. All four are included at each receiver station location. The cartoon in Figure 13 shows schematically how marine 4C seismic data are acquired using a cable system, which is laid on the seafloor. Generally, two vessels are used: one a source vessel, and the other a cable deployment and recording vessel.

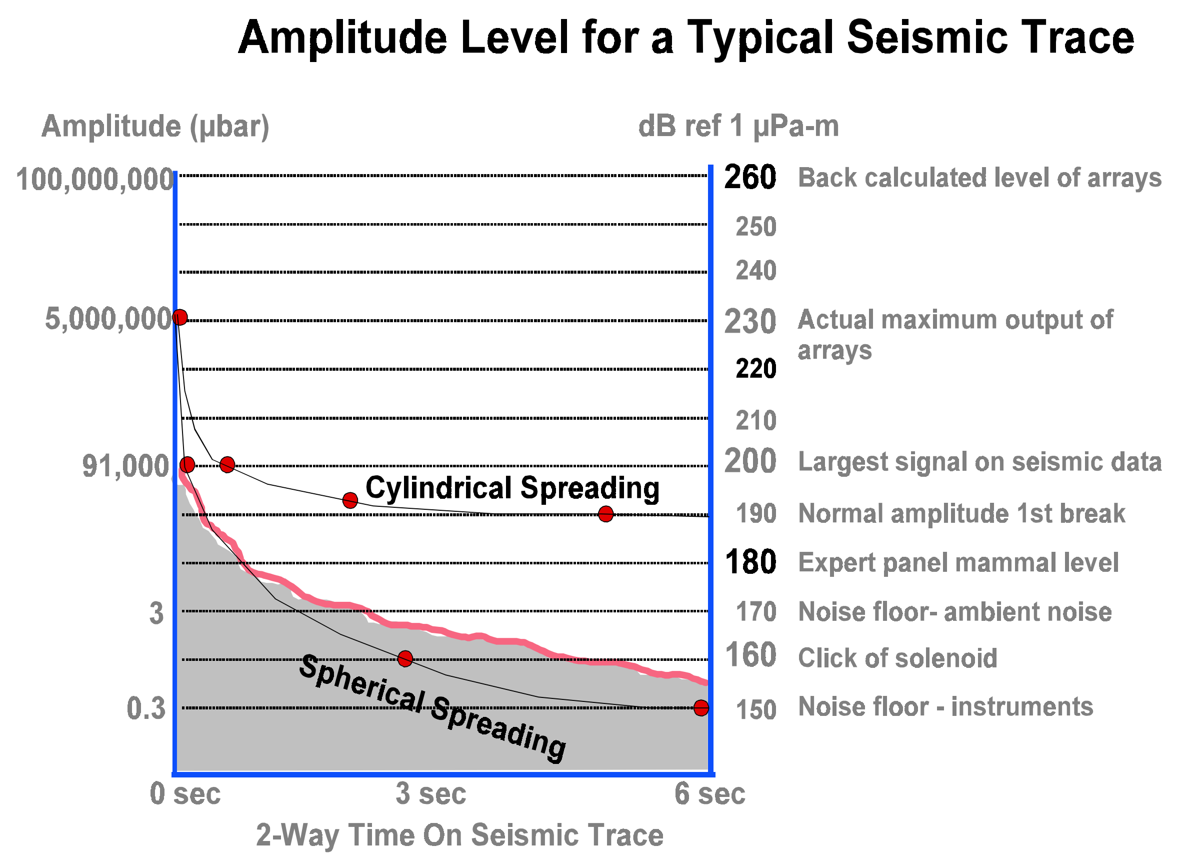


Figure 12. The amplitude level for a typical seismic trace as a function of recording time (the heavy line).

The seabed sensor systems routinely deliver data of higher quality than conventional towed-streamer data. There are several reasons for this difference: higher fold, less smear, broader bandwidth, the absence of towing and weather-related noise, and the ability to combine the vertical geophone output with the hydrophone output (combining these outputs results in the removal of much downgoing multiple energy). But fact that these cables deliver better data than towed streamers is not the only reason for going to the hardship and expense of deploying such seabed systems. Even more important is the ability of these systems to record a type of wave not recordable by streamers, and this is the shear (S-) wave. Conventional towed streamer marine systems only record compressional (P-) waves. When a P-wave passes through a rock, its behavior is affected by both the matrix of the rock (the solid part) and the pore spaces of the rock (that portion filled with liquids and/or gases). When an S-wave passes through a rock, however, its behavior is affected by only the matrix of the rock. Two other important properties of S-waves are that they travel at roughly half the speed of P-waves, and that they can not exist in fluids (hence the necessity of placing the recording sensors on the seafloor).

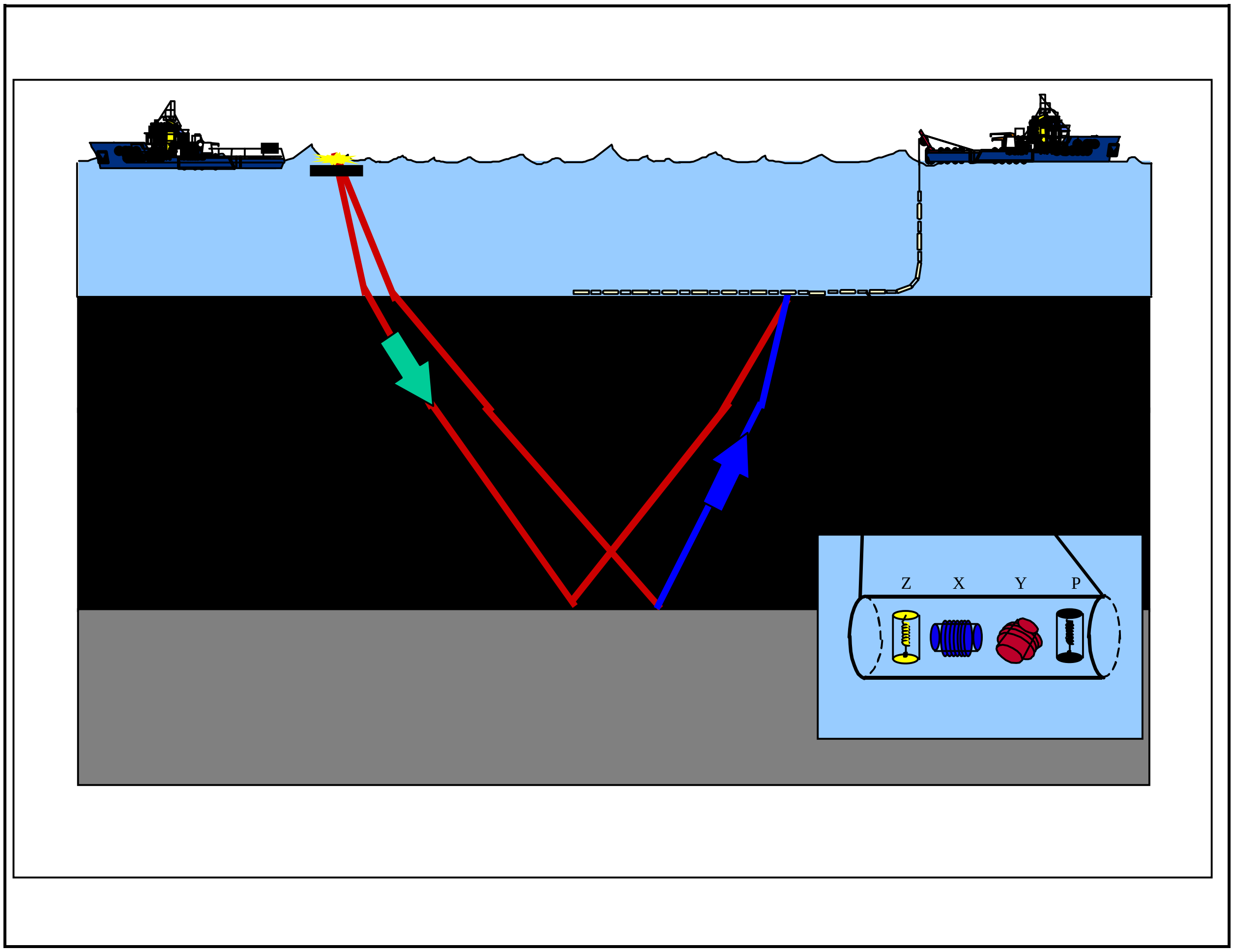


Figure 13. The cartoon shows schematically how marine 4- component seismic data are acquired using a cable system, which is laid on the seafloor. Generally, two vessels are used, one a source vessel and the other a cable deployment and recording vessel.

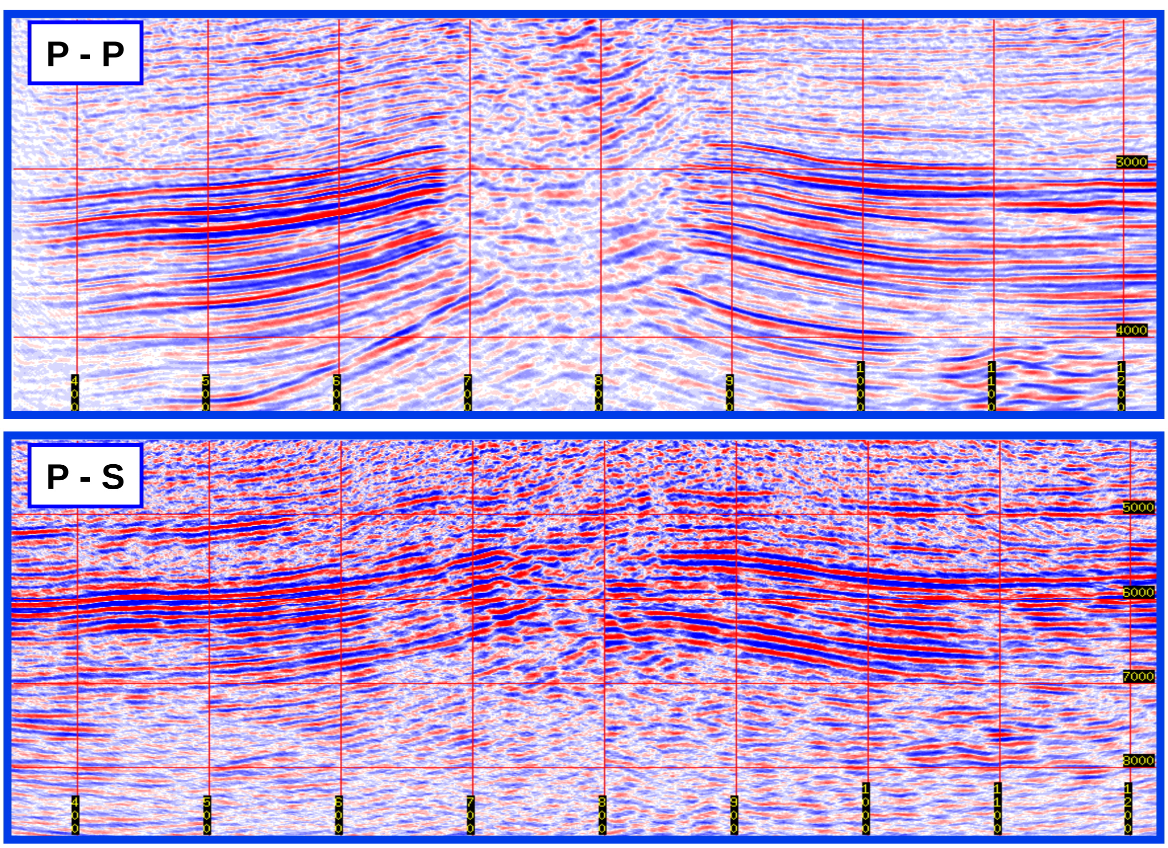
The recording of both of these wave types makes it possible to infer much more information about the rocks in the subsurface and the fluids they contain. It is the hope of acquiring this additional information has caused the industry's recent strong and active interest in recording both P-waves and S-waves. There are several applications of this technology that apply equally well in both the onshore and offshore environments:

- Improved lithology (mineralogy) prediction
- Improved pore fluid prediction
- Better S/N in areas of low P-wave impedance contrast or high P-wave attenuation
- Calibration for AVO (amplitude versus offset) studies
- Azimuthal anisotropy (the variation of seismic properties with horizontal direction)
- Another parameter for seismic reservoir monitoring (4D seismic).

Other applications, listed below, are primarily relevant to the offshore situation:

- Imaging within and beneath gas-invaded zones, shale diapirs, mud volcanoes
- Imaging base of salt, volcanics
- Illuminating P-wave shadow zones beneath salt bodies, particularly those with tops and/or bases that show significant topography
- Deepwater multiple removal
- Cost-effectiveness (compared to the cost of offshore wells).

Figure 14 is an example of imaging beneath gas using S-wave energy. This example, presented in 1994 (Berg, E., Svenning, B., and Martin, J., 1994, "SUMIC - A New Strategic Tool for Exploration and Reservoir Mapping," 56th Annual EAEG Meeting, Vienna), kick-started the interest in marine multicomponent. This figure shows the P-wave data (the PP section, which means P-wave downgoing energy and P-wave upgoing energy) being obliterated in the area of the gas chimney, whereas the PS section (P-wave downgoing energy and S-wave upgoing energy) provides a relatively clear picture beneath the gas. This application of 4C seismic has been successful in more



Courtesy of Statoil

Figure 14. An example of imaging beneath gas using S-wave energy.

than 20 cases since 1996. The other application with about the same number of successes is that of diagnosing the lithology and/or the fluids filling the pore spaces of a reservoir rock. Both of these applications are very important in field development work and reservoir management, so the interest in marine 4C seismology is quite high.

SEISMIC TIME-LAPSE MONITORING (STLM) OR 4D SEISMIC

Figure 15 depicts the basic concept of seismic time-lapse monitoring. An initial seismic survey is shot over a field and delineates the reservoir before any production occurs. The data are analyzed, and wells are drilled. After some period of production, another seismic survey is run, those data are interpreted and compared to the previous seismic data. Decisions are made as to where new wells need to be drilled. Those wells are drilled, and production continues. After some time, another seismic survey is acquired, and the sequence of events repeats.

If we could accurately picture the movement of fluids in a reservoir, then we could use that information to drill additional wells to drain the bypassed areas or otherwise better manage our reservoirs. It has been shown in a few published studies that seismic holds much promise in actually being able to monitor the movement of fluids when used in conjunction with all other data available (well log, geologic, core, production, etc.).

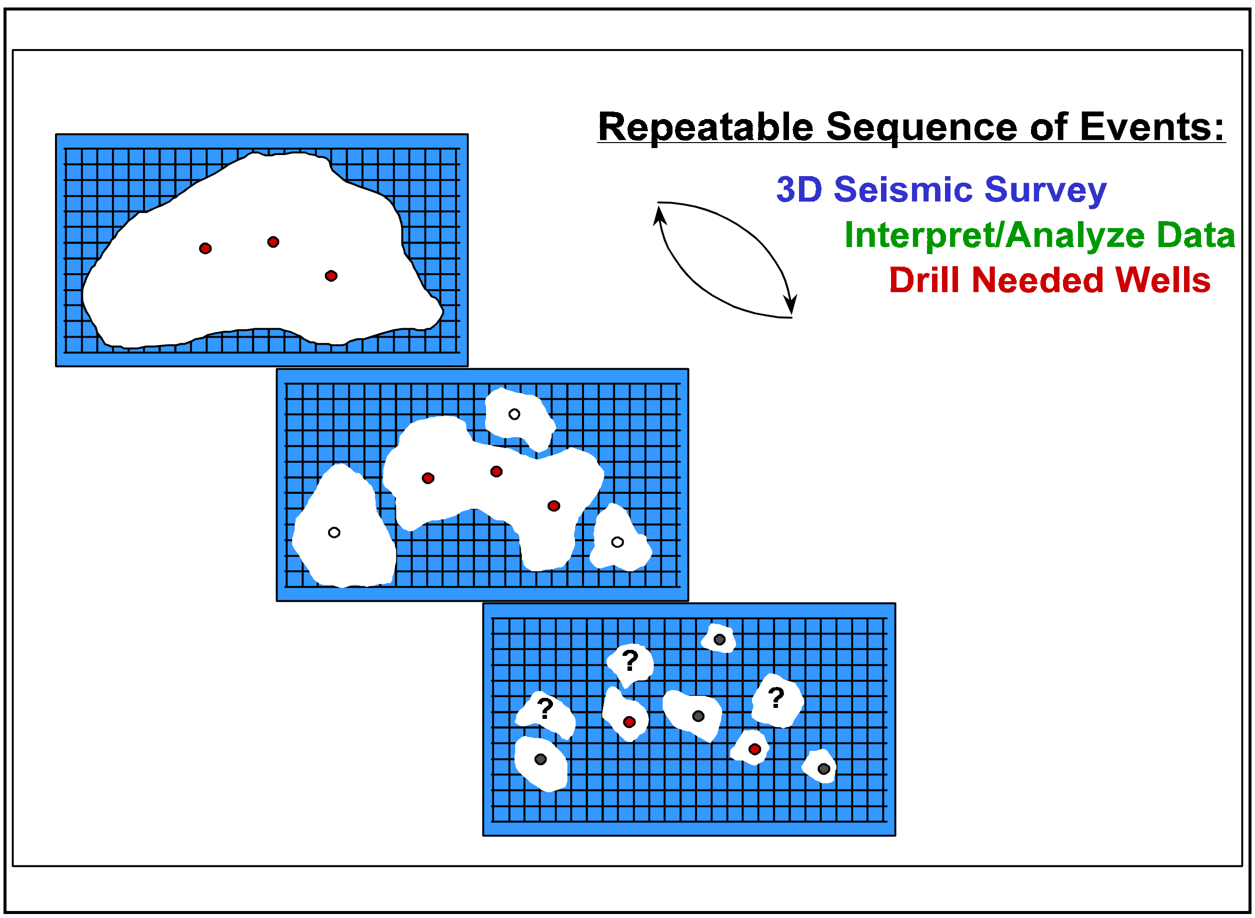


Figure 15. The basic concept of seismic time-lapse monitoring.

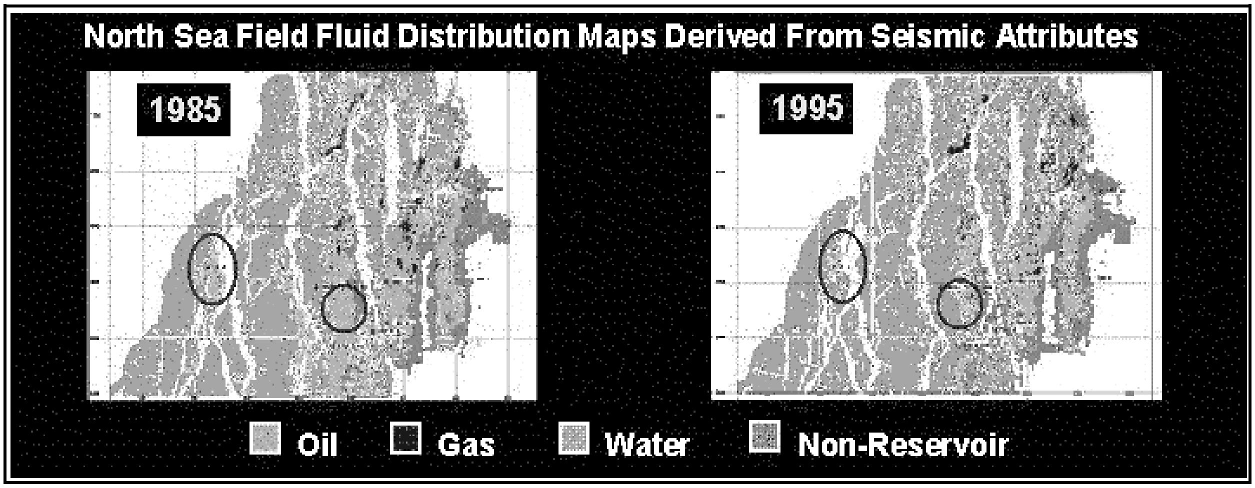


Figure 16. A real-world, North Sea field example where seismic attributes were used to map the fluid distribution in a reservoir under production.

Figure 16 shows a real-world, North Sea field example where seismic attributes were used to map the fluid distribution in a reservoir under production. 3D seismic surveys were shot in 1985 and 1995, although the survey shot in 1985 was not shot with time-lapse monitoring in mind. Both data sets were reprocessed so as to maximize the consistency in the two data sets.

Fourteen (14) seismic attributes were used to achieve the fluid characterization illustrated here. Although there are numerous places where there are differences in the depicted fluids, the circled areas show where perhaps the largest changes in the reservoir have occurred in the intervening time between the two surveys, indicating places where water has replaced oil. Subsequent drilling has confirmed the correctness of this picture.

The repeatability of one seismic survey to the next is probably the major question the industry has with respect to STLM. The following list of statements sums up the situation:

- Monitor surveys must look forward and backward
- Newer surveys must take advantage of advancements
- Newer surveys will be bastardized to compare to older surveys
- TLM objectives may be quantitative and/or qualitative
- Acquisition and processing will affect repeatability

While these statements are self-explanatory, the fourth one requires some clarification: if the information to be derived from a STLM project is quantitative, then more-than-likely, the repeatability will have to be greater than if the objectives are qualitative. So acceptable repeatability will be related to the desired objectives of the STLM. The major factors that may affect repeatability, outside of the reservoir changes themselves that we wish to see, include the seismic source, the elements of the seismic acquisition system, the processing system, the weather, and the structures and facilities associated with the producing oil field:

- Is the source itself repeatable? Is its coupling repeatable? Does the source occupy exactly the same positions in a later survey as it did in an earlier survey (location)? Do we assign to the source the proper location (positioning)?
- Is the receiver itself repeatable? Is its coupling repeatable? Does the receiver occupy exactly the same positions in a later survey as it did in an earlier survey (location)? Do we assign to the receiver the proper location (positioning)?
- Was the same recording system used in all surveys that are to be compared? Are the system responses the same from survey to survey? Were the acquisition parameters (filter settings, etc.) set in the system the same way for all surveys?
- Were weather conditions the same for all surveys, and were the surveys done at the same time of year? Was wind/precipitation noise the same for all surveys? Was the sea state the same, or were wave action/currents much worse for one survey than for another? Was the ground wet, frozen, ploughed, snow-covered, etc., for all surveys?
- Are there facilities present now that were not there for earlier surveys and are the same facilities running the same way as they were for earlier surveys?

To do quantitative STLM, we have to be able to address many of these questions. As we move from quantitative STLM to qualitative STLM, the importance of repeatability diminishes but certainly does not completely go away.

Partly to address some of the repeatability issues, and partly to acquire higher quality and/or more complete seismic data, the industry is beginning to use cables placed on the seafloor, or trenched down into it, and vertical arrays of cables containing many sensors. The reasons for burying cables are (1) to improve repeatability from survey to survey by ensuring that the receivers are in exactly the same position for each survey, (2) to ensure higher quality data because the sensors are in a quieter environment on the seafloor than they are when being towed near the sea surface, (3) to reduce sensitivity to weather, and (4) to reduce overall cost when doing numerous repeat surveys.

Figure 17 depicts an array of vertical cables and the trenching of a cable into the seafloor. Cables laid temporarily on the seafloor, as well as vertical cables, provide true 3D seismic, equivalent to land 3D, in which full and complete azimuth and offset distribution can be achieved, unlike marine towed streamer 3D in which the azimuth distributions are quite limited due to the swath style of shooting (the sources are essentially inline with the streamer receivers).

SUMMARY

This paper has attempted to provide a brief overview of some of the continued improvements and recent advances being made in the marine seismic industry, as well as to provide a short summary of airgun array practices and technology. A constant stream of new developments has been ongoing for some time, and it does not look to abate in the near future. Conventional towed streamer 3D surveys will continue to be done more efficiently and to deliver higher data quality than past methods have produced. Time-lapse seismic monitoring and 4C seismic will become important technologies delivered by the seismic contractors for improved reservoir characterization and management. A primary goal of this paper has been to disseminate information about how the seismic industry conducts its data gathering. This is done in the hope that it will foster better

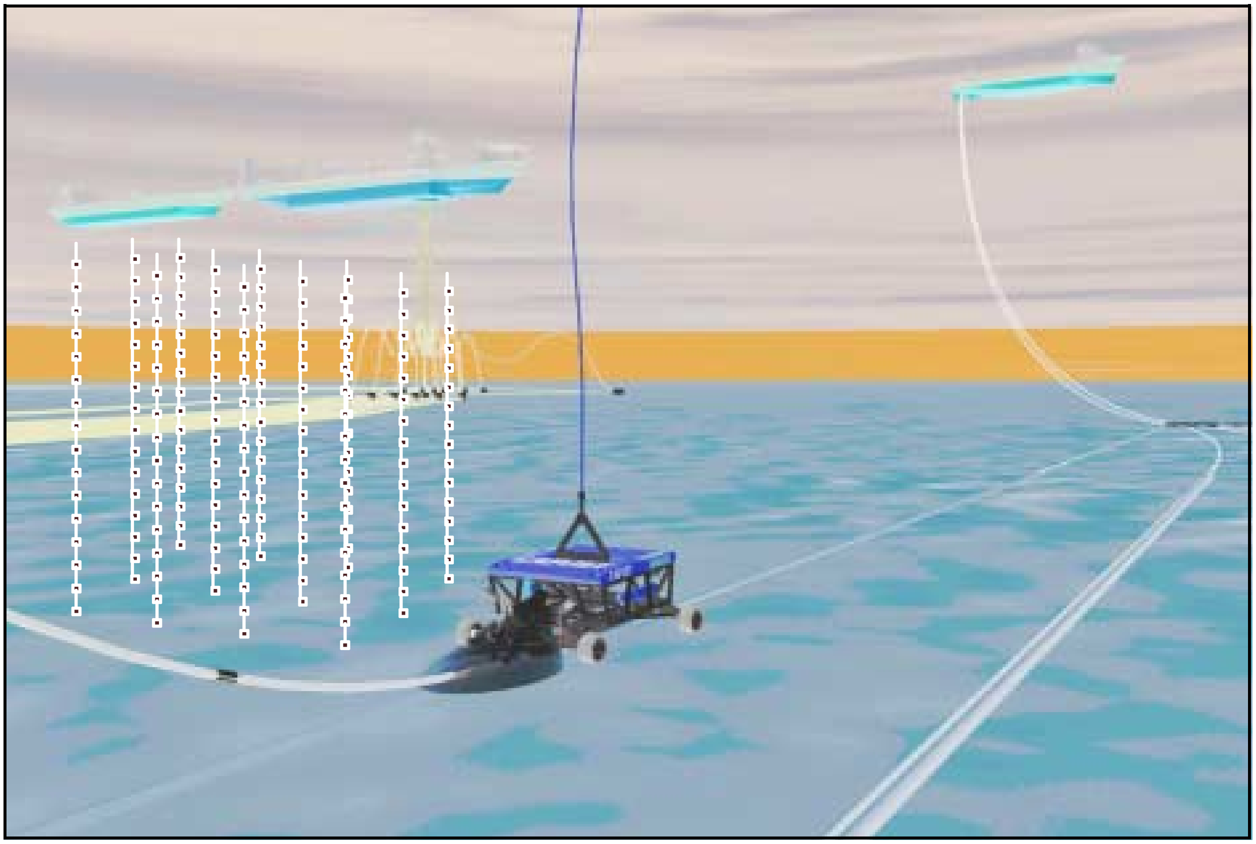


Figure 17. A depiction of an array of vertical cables, and the trenching of a cable into the seafloor.

cooperation and communication among the various groups interested in the well-being of our oceans and its inhabitants.

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BIOLOGICAL IMPACTS OF UNDERWATER EXPLOSIVES USED IN PLATFORM SALVAGE IN THE GULF OF MEXICO

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National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Center
Galveston, Texas

BACKGROUND

During a one-month time span in the spring of 1986, 51 dead sea turtles and 41 dead dolphins washed ashore near Galveston, Texas. During the first two weeks of this period, a series of at least 22 explosions occurred in conjunction with oilfield structure removals a few miles offshore. This raised serious concern over the potential impact of these activities on endangered and protected species of sea turtles and marine mammals since there are roughly 4,000 oil and gas structures in the Gulf of Mexico and all of them must be removed eventually. As a result, under the auspices of the Endangered Species Act an Incidental Take Statement (Table 5) was prepared which listed requirements aimed at protecting sea turtles. Beginning in 1987, an observer program was established to monitor every structure removal in the U.S. Gulf of Mexico where more than 5 lb or 2.3 kilos of explosives were used. From 1987-1999 a total of 1,175 structures (average of 90 per year) were monitored by National Marine Fisheries Service personnel.

Table 5. Summary of Incidental Take Statement for Sea Turtles.

1.	Qualified observers monitor for sea turtles beginning 48 hours prior to detonations.
2.	30 minute aerial surveys within one hour prior to and after detonation.
3.	If sea turtles are observed within 914 m of the structure, detonations will be delayed until attempts are successful in removing them at least 914 m and the aerial survey must be repeated.
4.	No detonations will occur at night.
5.	During salvage-related diving, divers must report sea turtle and marine mammal sightings. If sea turtles are thought to be resident, pre- and post-detonation diver surveys must be conducted.
6.	Detonation of explosive charges must be staggered to minimize cumulative effects of the explosions.
7.	Avoid use of “scare” charges to frighten away sea turtles which may actually be attracted to feed on dead marine life and subsequently exposed to explosions.
8.	Removal company must file a report summarizing the results.

In addition to sea turtles, observers also watched for marine mammals. In November 1995 an official authorization for marine mammals was finalized. For companies requesting an authorized take of marine mammals, requirements are the same as for sea turtles, plus the following:

1. No waivers can be given for aerial surveys (aerial survey's are sometimes waived if bad weather precludes flying).
2. In addition to the aerial survey, which must be performed within an hour after each blasting event, either an ROV or diver survey must be conducted within 24 hours or an aerial or vessel survey must be conducted within 2-7 days.

RESULTS

The following are some of the highlights of the Platform Removal Sea Turtle Observer Program. Monitoring effort was partitioned by surveys conducted from vessels and platforms at the sea surface during the day and at night and from aerial surveys that were only performed during daylight hours. Most monitoring occurred during the day, somewhat less monitoring at night, and a very small amount during aerial surveys. Results were standardized by dividing the number of individual turtles observed by the number of monitoring hours for each survey method to yield the turtle observation rate. From 1986-94 day and night sea turtle observation rates from surface surveys were about the same, but the aerial survey rate was 10 times higher. For the 1986-98 period this value was 17 times higher, which attests to the great superiority of aerial surveys over surface surveys in detecting the presence of sea turtles.

From 1986-1998, 576 lease blocks were monitored. Lease blocks typically measure about 2 nautical miles or 4 km on a side. National Marine Fisheries Service personnel observed 127 individual sea turtles at 22% of monitored blocks. Most turtles that occur at offshore removal sites are loggerheads, although all of the five species that occur in the western Gulf of Mexico have been observed. One turtle was reported killed in 1986 during opportunistic monitoring and prior to the official beginning of the observer program in 1987. Since 1987 one additional loggerhead turtle was killed by explosives and two more were injured, rehabilitated and released back into the Gulf of Mexico. Nine turtles were captured during the program. Seven of these captures occurred prior to detonation of explosives, indicating that these animals were saved from potentially lethal blast impacts.

From 1986-1994 nearly 19,000 sightings of marine mammals including bottlenose and spotted dolphin were recorded. Because many of the observations may have been resightings, this value should not be taken as a population estimate. Of the 576 lease blocks monitored, 483 or 84% had dolphins. No killed or injured dolphins were observed and none were captured during the program.

PROTECTING “PROTECTED SPECIES” FROM DETONATIONS

Current Practices

When dolphins and sea turtles are encountered at explosive structure removal sites, there is little in our arsenal of techniques to coax them out of the designated 1,000 m impact zone. When dolphins are present, attempts are made to move them out of the area using a vessel in the hope that they will ride the bow or stern waves. If this is unsuccessful then a very small explosive charge (6 ft of detonation cord) is detonated in an attempt to scare the animals from the area. These procedures are "hit or miss" and many times all that can be done is to delay the detonation of structure-severing explosives until the animals move off of their own volition. When sea turtles are observed, then diver surveys are made to attempt capture of the animal prior to detonations. While capture rarely occurs, the presence of a diver in some cases may at least disturb the turtle and set it in motion from beneath the platform.

Information Needs

A high degree of protection can be afforded protected species if explosive structure removals can be scheduled at times and places when these species are not present. Although this may not always be possible due to industry needs, knowing where and when protected species occur is essential information for this process. A few "hot spots" of sea turtle activity are known. For example, Kemp's ridley sea turtles occur in relatively large numbers near Sabine Pass, Texas in spring and loggerheads nest on the Chandeleur Islands in spring and summer.

Technology

A technological "fix" to protect sea turtles and marine mammals from explosive impacts has not occurred. Recent research into the development of charge designs that release less energy into the water column have the potential to significantly reduce the size of the impact zone. Pressure dampening devices such as mats or bubble curtains have also been mentioned in this regard but are not being used for several reasons. The degree to which bubble curtains and mats would reduce the impact distance has not been researched and may or may not be theoretically effective, cost effective, or logistically feasible. The use of acoustic signals, food, etc. to attract or repel sea turtles and dolphins from the impact zone has not been thoroughly researched and presents complex logistical issues. However, experimental testing of specific stimuli, such as killer whale sounds to repel dolphins, may be cost effective and warrant research.

CONCLUSIONS

Impacts of underwater explosives on sea turtles and marine mammals appear to be small in comparison to other sources of mortality when requirements of the Incidental Take Statement are met. However, impact assessment is limited primarily to dead and seriously injured animals that appear at the surface shortly after explosives are detonated. Sublethal impacts that do not result in immediate abnormal behavior at the sea surface are not really assessed well with current monitoring protocols. Although not a panacea, use of acoustical signals (such as testing effects of killer whale sounds on dolphin movements) to move sea turtles and marine mammals from the impact zone immediately before detonations may warrant research.

NAVY EXPLOSIVES TESTING

Mr. William Sloger
Department of the Navy

The DDG 81 Shock Trial is the latest in a series of shock trials done for each new class of Navy ships (Figure 18). The DDG 81 represents a major upgrade to the DDG 51 Arleigh Burke class, which will represent the major force in the surface Navy by 2010.

The shock trial is in a number of ways very similar to the last shock trial the Navy planned, for the SeaWolf submarine, which is scheduled for next summer but will not likely occur. These shock trials, which are required by law (10 USC 2366), are intended to test a ship's survivability and combat readiness in an underwater explosion environment and to lead to improvements where needed. The DDG 81 shock trial will consist of the detonation of three 10,000-pound charges at the rate of one per week. Each succeeding detonation will place the charge progressively closer to the

Figure 18. Flight IIA guided missile destroyer (DDG), Winston S. Churchill.

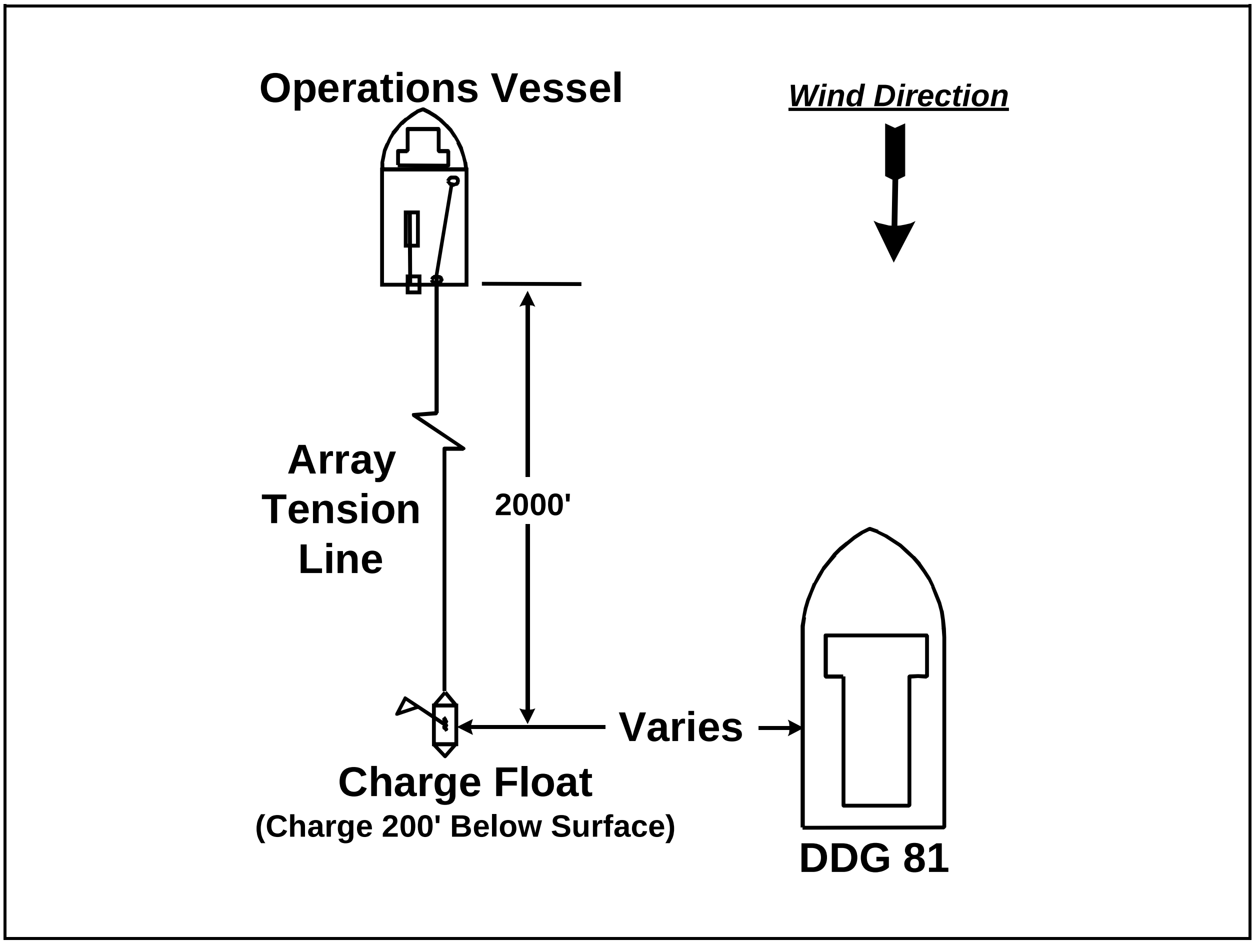

Figure 19. Explosive shock trail components.

ship to increase the intensity of the shock wave propagated through the ship's hull. The shock trial is planned to occur between 1 May and 30 September 2001 (Figure 19).

Putting together the Draft EIS for this shock trial, we plan to complete the NEPA process with a Record of Decision in the spring of 2001. The EIS is also being produced in accordance with Executive Order 12114, which applies to Federal actions in the global commons. The requirements of the Endangered Species Act (ESA), Marine Mammal Protection Act (MMPA), Coastal Zone Management Act (CZMA), and Magnuson-Stevens Act will also be met. The Navy is also working very closely with National Marine Fisheries Service (NMFS), which has agreed to act as a cooperating agency in development of the EIS.

We went through two preliminary phases before beginning the NEPA process. The first was an operational evaluation of the test and what locations could actually support it. We began by looking at all Navy bases on the West, Gulf, and East coasts, a total of 16 bases. After evaluating these bases against a fairly lengthy list of operational criteria, we narrowed the field to three areas: Norfolk, Mayport, and Pascagoula (Figure 20). Some of the criteria included: Navy personnel tempo requirements, proximity to a naval base with certain assets (support ships, planes, repair facilities),

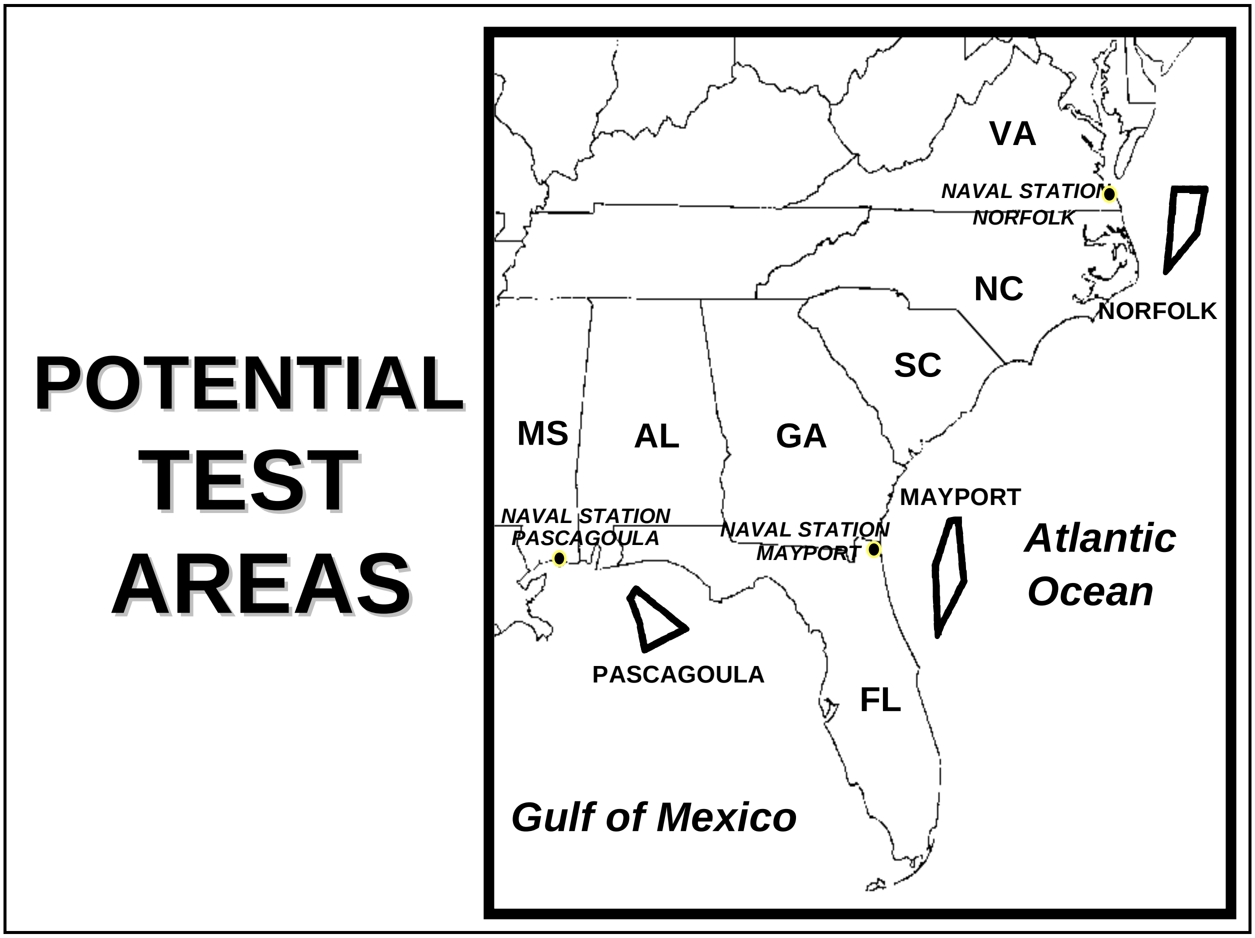

Figure 20. Potential test areas.

ship traffic, and weather. All three of these areas were considered operationally equal, so the final selection of a single area will be based on environmental factors.

The next phase was a review of the literature for the three sites. The purpose of this phase was to describe environmental conditions in each area and develop maps of environmental constraints. It would also provide a basis for the affected environment section of the EIS. The review of the literature showed that the potential for presence of marine mammals and turtles is somewhat similar at the three areas (Table 6). At Norfolk, up to 35 marine mammal species may be present, including 7 mysticetes, 27 odontocetes, and 1 pinniped. For all of these totals, both listed and non-listed species are included, as well as those that are unlikely to be present based on low frequency of sightings. At Mayport, up to 29 marine mammal species may be present, including 7 mysticetes and 22 odontocetes. At Pascagoula, up to 29 marine mammal species may be present, including 7 mysticetes, 21 odontocetes, and 1 exotic pinniped (California Sea Lion). Five species of sea turtles may occur at any of the three test areas. We do know, however, that Norfolk will likely be the first area to drop from further consideration due to the results of past surveys which indicate higher densities of mammals.

Table 6. Calculated Critical TTS Distances (Nautical Miles).

Norfolk		
Depth(ft)	Mysticetes	Odontocetes
600	15.0	9.0
6,000	23.0	17.0
7,700	21.0	17.7
Mayport		
Depth	Mysticetes	Odontocetes
600	13.0	8.0
1,200	13.0	11.0
2,300	15.0	13.6
Pascagoula		
Depth	Mysticetes	Odontocetes
600	12.3	8.6
1,200	16.0	10.0
2,200	14.4	13.3

Two criteria basically define the bounds of the areas we are looking at: a minimum water depth of 600 feet and a maximum distance from shore of 100 nautical miles. Within these areas we encounter water depths up to 8,400 feet at Norfolk, 2,800 feet at Mayport, and 2,300 feet at Pascagoula. The total square mileage within the three candidate areas ranges from 1,600 nmi^2 at Pascagoula to 2,300 nmi^2 at Mayport. Other features that likely will influence the candidate test areas include the Gulf Stream at Mayport and the Loop Current at Pascagoula.

Presence of marine mammals and turtles in the candidate areas is the Navy's greatest concern. For that reason, we are going through a series of very conservative steps to ensure that the final test site within a given test area will have a very low likelihood of having mammals or turtles present. In the Draft EIS, we will name a preferred test area, which will be chosen based on its having the lowest estimated marine mammal and turtle densities. We will generate those estimates from data received from several sources. For Norfolk, we will use data primarily from a series of cruises done by the NMFS Northeast Science Center during the 1990s. These include cruises by the Chapman, the Delaware, the Pelican, and the Abel-J. For Mayport, we will be flying aerial surveys twice this summer. And for Pascagoula, we will use aerial survey data from GulfCet II. The next in this series of steps will be to fly aerial surveys of the test area in the week before the first detonation. Based on the results of these flights, a primary test site as well as two back-up sites will be chosen from within the particular area. On the day of each detonation a very extensive monitoring and mitigation program will be in effect. It will include aerial observers, shipboard observers, and an acoustic monitoring system. The monitoring program is designed to ensure the test area is free of marine mammals and turtles at the time of detonation (Figures 21, 22, 23).

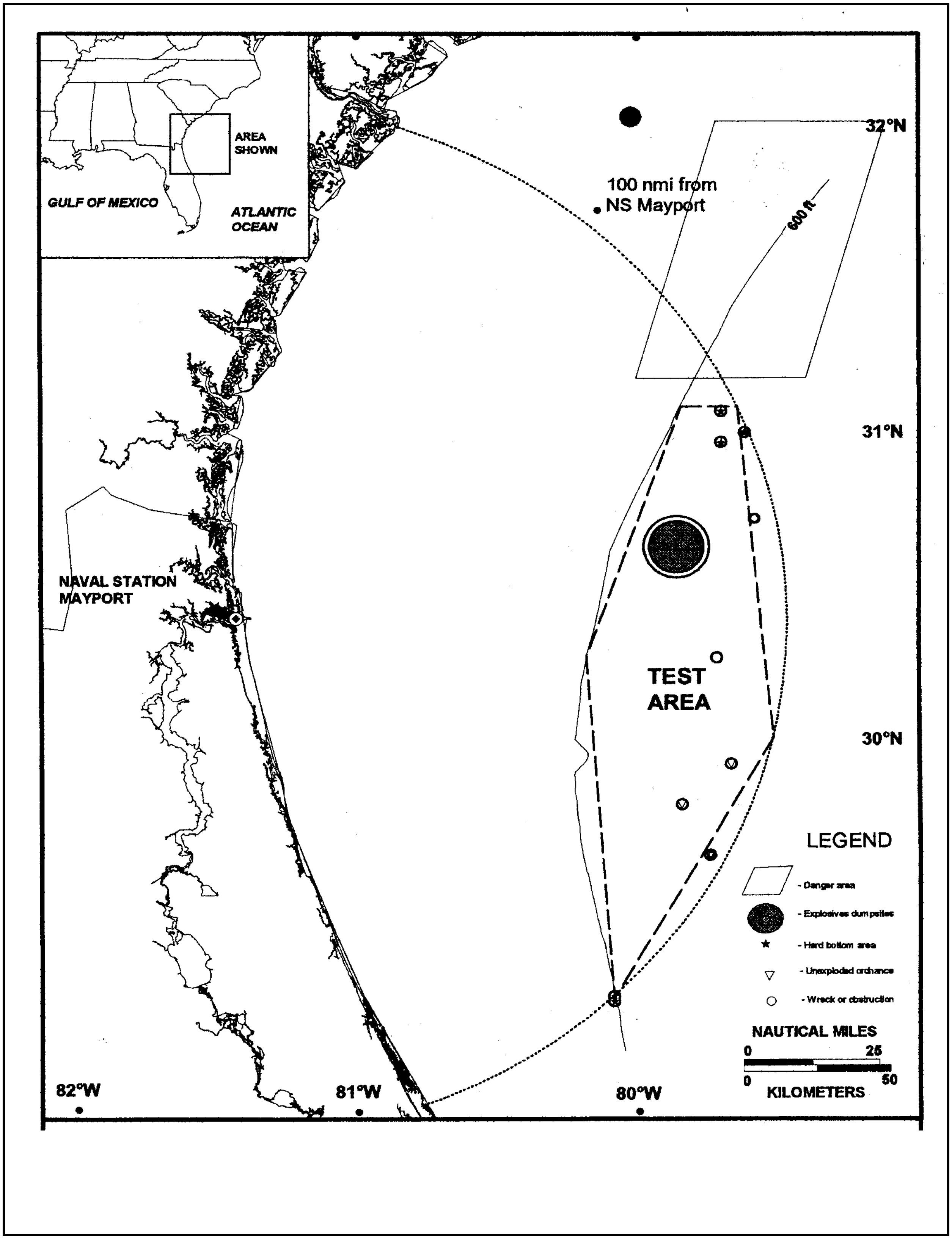

Figure 21. Exclusionary map of the Mayport test area.

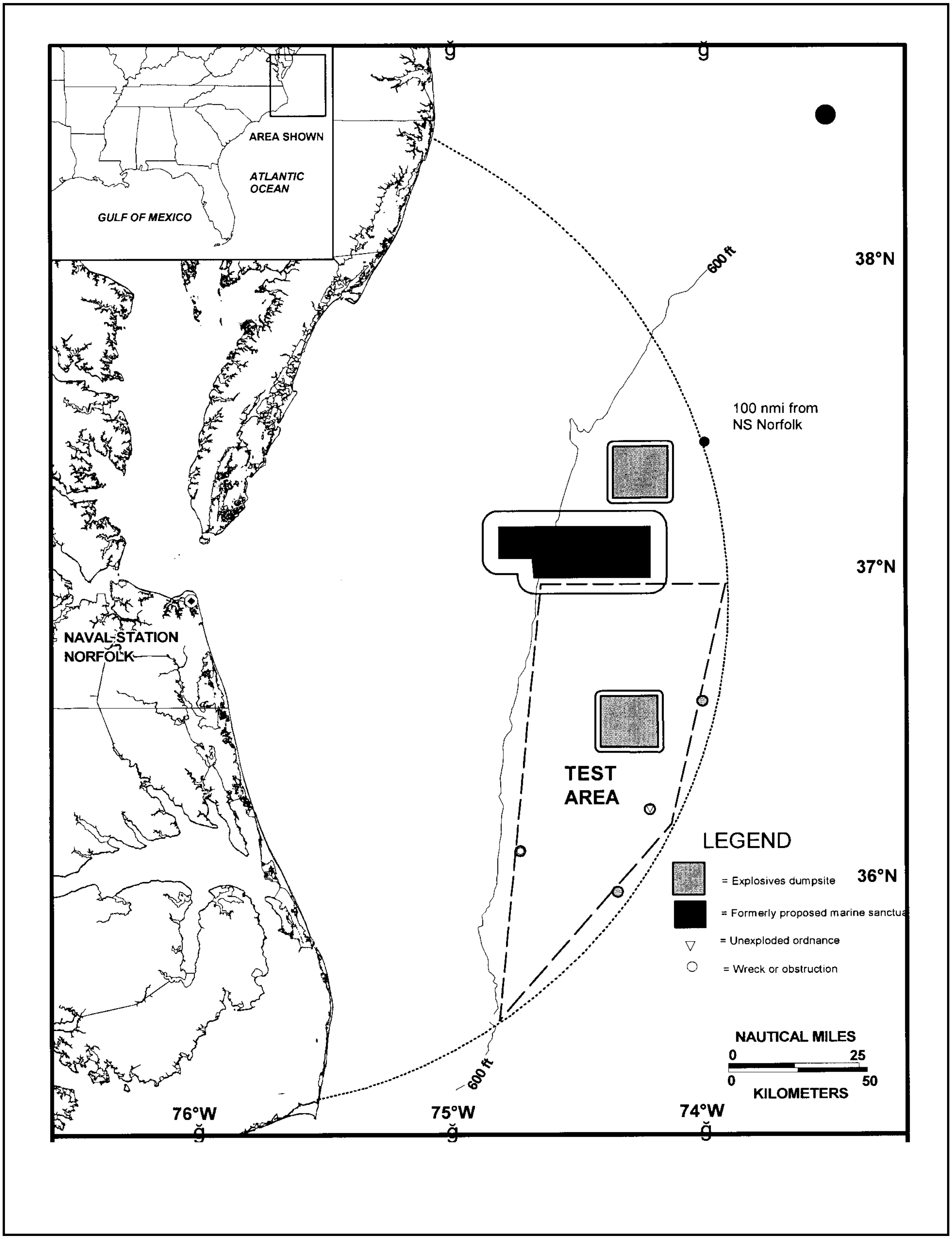

Figure 22. Exclusionary map of the Norfolk test area.

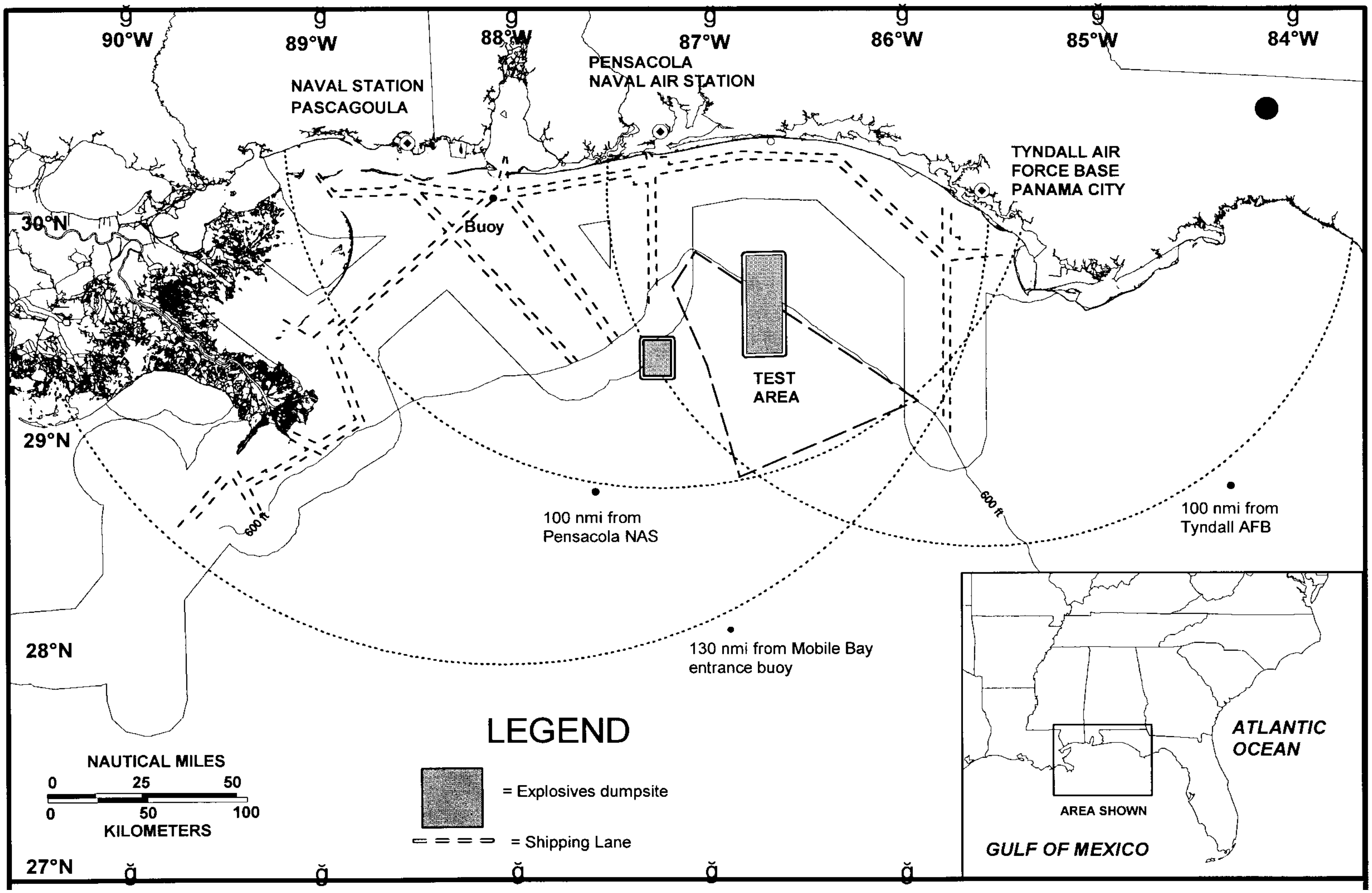

Figure 23. Exclusionary map of the Pascagoula test area.

Because this test may affect marine mammals and turtles, the Navy will submit an application to NMFS for an incidental take permit. We will calculate the regions of influence from the detonations much as they were calculated for the SeaWolf shock trial several years ago. Mortality is defined by onset of extensive lung injury in a calf dolphin. This results in a range of under one mile. The injury range is defined by 50% TM rupture. As with mortality, it is assumed that 100% of the animals within this range would be affected. This range is a little over one mile. These are the areas of greatest concern to us. The efforts previously mentioned regarding test day monitoring will focus on an area that will be approximately double the injury range.

The other effect the shock trial may have on marine mammals and turtles is auditory threshold shift. We have quantified the impact of harassment, as was previously done for the SeaWolf program, through the use of temporary threshold shift (TTS). The TTS criteria will be used to develop estimates of acoustic impact ranges for marine mammals and turtles, to estimate extent of harassment. We will use two criterion to define a given position in the water column at which TTS would not be expected to occur: (1) whether the peak pressure is less than 12 psi, and (2) whether the energy density in all 1/3 octave bands is less than 182 dB re $1mPa^2$ m sec. Different frequency ranges will be used for odontocetes and mysticetes due to differences in low frequency hearing sensitivity. For odontocetes we will look at frequencies > 100 Hz, and for mysticetes frequencies > 10 Hz.

The pressure-time waveforms were calculated using the REFMS computer model for shock wave transmission. This model includes the effects of multiple surface and bottom reflections of the shock wave as well as refractive effects. The results vary from site to site partly due to the sound speed profile of the water at a site and partly due to water depth.

Following the schedule we are currently on, we plan to have the Draft EIS out to the public at the beginning of December of 1999.

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HUMAN ACTIVITIES AND NATURAL EVENTS: IMPACTS ON GULF OF MEXICO MARINE MAMMALS, PART 1

Dr. Bernd Würsig
Texas A&M University

The Gulf of Mexico ecosystem is enormously diverse and ever-changing. Up north and near shore, cold winters can bring slush ice to its channels and bayous; down south, true tropical conditions reign. And in deep waters, the warm Yucatan Current invades from the Caribbean Sea, buds off gyres and eddies as it flows into the northern Gulf, loops towards the east through the Florida Straits, and joins the Gulf Stream. Warm core anticyclonic eddies spawn cold core cyclonic siblings, and the areas between the two, or confluences, are particularly rich in marine life. The system is largely wind-driven, and we can expect that anomalous hurricane years, for example, can result in large-scale differences in gyre formation and resultant prey for marine mammals, sea turtles, and birds (Biggs *et al.* 1996; Davis *et al.* 1998).

Thirty years ago, researchers and the public had only a vague impression that the deeper waters of the Gulf harbor more than the near-shore bottlenose (*Tursiops truncatus*) and Atlantic spotted (*Stenella frontalis*) dolphins of the inner shelf. It was David Schmidly and Susan Shane of Texas A&M University (Schmidly and Shane 1978) who most concisely pointed out the Gulf's amazing cetacean diversity, knowledge gleaned largely from stranding records and the whaling literature on sperm whales (*Physeter macrocephalus*). Indeed, there are sperm whale concentrations in at least three areas, north of the Florida Keys, south of the Mississippi Delta, and just east of the Texas-Mexico border (Würsig *et al. in press*). At least another twenty toothed whales "commonly" occur in Gulf waters, as well as two species of baleen whales, the generally tropical Bryde's (*Balaenoptera edeni*) and the near-cosmopolitan humpback (*Megaptera novaeangliae*) whales. Clymene dolphins (*S. clymene*) and short-finned pilot whales (*Globicephala macrorhynchus*) prefer shelf waters west of the Mississippi; spinner (*S. longirostris*) and Atlantic spotted dolphins prefer those east of it; and pantropical spotted (*S. attenuata*) and striped (*S. coeruleoalba*) dolphins occur in deep waters throughout the northern Gulf. We know that at least sperm whales and several of the *Stenella* spp. are found more frequently than expected in and near confluences between ocean eddies or gyres, and less frequently in warm anticyclonic rings. While present for much or all of the year, most cetaceans change their locations based in part on seasonal conditions and in part on unpredictable vagaries of ocean systems (Davis *et al.* 1999).

Besides the influences of depth, area, season, and oceanographic features, we expect that geographically large-scale and temporally long-term changes in ocean climate can have profound effects on cetacean abundance, distribution, and overall "health" in the Gulf. Such large-scale changes would be induced by global climate change, and it is generally agreed that at present we are in the midst of largely (or totally) human-induced global warming (IWC 1997; Tynan and DeMaster 1997). However, predictions of potential effects are fraught with difficulty. It is probable that ocean warming will spawn more frequent and violent weather patterns including hurricanes, and may change eddy formations, river input to the Gulf, salinities, and primary productivities in ways that may strongly affect marine mammals. Only long-term monitoring of climate, ocean processes, and marine mammals in the Gulf can bring hope of discerning potential and realized problems due to global climate change (IWC 1996; Würsig and Ortega-Ortiz 1999).

Human action has had strong influences on marine ecosystems, especially by pollution and other forms of habitat degradation near shore (see, for examples, Würsig 1990a; Leatherwood and Jefferson 1997). In the Gulf of Mexico, high levels of bio-accumulated metals, PCB's, DDT, and other potential toxins have been found in near-shore bottlenose dolphins (Davis 1993; Salata *et al.* 1995). At the same time, an unusually high incidence of abnormal internal and external body growths and lesions, some of which are pathological, have been found during necropsies of beach cast dolphins (e.g., Cowan 1995). Links between toxins and pathologies have only rarely been made for cetaceans, but see Aguilar and Borrell (1994) for an example, and Aguilar and Borrell (1996) for excellent summaries.

Since petrochemical production is a major industry in U.S. waters, including the Gulf of Mexico, the question of potential danger to marine mammals due to oil spills has been addressed (Geraci and St. Aubin 1990). Pinnipeds are subject to oil fouling of the pelage, and consequent reduction of thermoregulatory ability, especially by fur seals; baleen whales may suffer at least short-term baleen fouling; and manatees(*Trichechus sp.*) could suffer poisoning if ingesting water and sea grasses in oil-polluted near shore areas. However, it had been surmised that toothed whales, the predominant marine mammal fauna in the Gulf, might not be subject to more than brief and mild physiological damage since toothed whales do not generally ingest near-surface prey, and thermoregulate with blubber instead of hair (Würsig 1990b). This belief was modified when it was found during a 1990 oil spill off Galveston, Texas, that bottlenose dolphins remained in even the very volatile freshly-spilled surface sheen and slick oil, apparently unable to detect a way out of the affected area. Although no deaths of offshore bottlenose dolphins were detected as a result of the oil spill (due to currents at the time, carcasses would have been unlikely to float ashore), the dolphins were inhaling volatiles of potential danger to lung and other internal tissues (Smultea and Würsig 1995). It is therefore probable that oil spills pose a threat to even toothed cetaceans who are mobile enough to "easily" leave the area of the oil spill, but may not know how to do this. However, the magnitude of such potential threat is unknown, and research is urged on this point.

It is known mainly from studies outside of the Gulf of Mexico, that dolphins and whales can be affected to variable degree by human-made sound from boating and shipping; petrochemical exploration, development, and extraction; and ocean science studies (such as loud low-frequency sounds that synoptically measure ocean temperature by recording of speed of sound) (summaries are in Richardson 1995, and Richardson and Würsig 1995, 1997). The petrochemical exploration noise of "pinging" seismic exploration is particularly loud, and can affect behavior of cetaceans to distances of tens of kilometers (for example, Malme *et al.* 1984). Short-beaked common dolphins (*Delphinus delphis*) adjusted their movements at least by several kilometers in response to industrial seismic activities (Goold 1996). While it has been asserted that sperm whales changed their distribution patterns in response to seismic sounds in the Gulf (Mate *et al.* 1994), such reaction has not yet been proven and remains to be studied.

Recent evidence indicates that types of calls and calling rates of whales and dolphins may be affected by industrial noise (Rendell and Gordon 1999, long-finned pilot whale, *Globicephala* *melas*), and by sounds of vessels (Lesage *et al.* 1999, beluga whales, *Delphinapterus leucas*). Communication may be disrupted, altered, or masked by industrial noise (Greene 1995). Physiologic changes, such as enlarged adrenal glands and shifts in hormone levels, have been documented in terrestrial mammals subject to long-term noise (Harlow *et al.* 1992). However, clear physiologic effects of stress have not been investigated in cetaceans, and this area of research is in obvious need of attention.

Dolphins and whales are likely to have habituated at least to some aspects of high levels of shipping noise and industrial activities, especially of the northern Gulf of Mexico; but it is presently unknown what types and intensities of underwater noises may change the distribution patterns, habitat use, general behaviors, or physiology of any of the cetaceans. Since large gyres and eddies seem particularly important to at least several cetaceans (Davis *et al.* 1999), it follows that such areas of high use by marine mammals have the potential of being most vulnerable to disturbance from industrial activities and shipping. I suggest that reactions to disturbance be studied in dolphins and whales inhabiting waters with presently or projected high amounts of human activity. Sperm whales are a concern as a listed endangered species, and since very little is known about any of the smaller toothed whales, or dolphins, one or two such species might be used as “indicators” for others. A set of well-designed experimental studies, probably including controlled sound sources, underwater acoustic measurements of the sources and the animals, and devices that monitor movements and dives can be part of such work. There is a critical need for information on disturbance reactions of cetaceans in the Gulf of Mexico, and it is hoped that data gaps are filled in as soon as possible in the face of continuing and accelerating industrial use.

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HUMAN ACTIVITIES AND NATURAL EVENTS: IMPACTS ON GULF OF MEXICO MARINE MAMMALS, PART 2

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THE EFFECTS OF NOISE ON ANIMALS

In the marine environment, there are many sources of noise, as is true in any environment. We may think that we understand how noise affects us, particularly loud noise, such as a jet flying overhead or an explosion of fireworks. But few of us can imagine what a 240 dB seismic pulse sounds like and what its affects might be when it is repeated at 15 second intervals for days on end. When a noise like this is transmitted in water, which is a more efficient conductor than air, its effects are tremendous. To put this example in perspective: a 10-pound charge of TNT exploded at a depth of 50 feet generates a signal of approximately 223 dB. (Urick 1983).

We humans are very rarely exposed to such sound levels, and it is hard to say how we would respond if we were exposed to such sounds. It seems logical that any animal exposed to such signals would have obvious and immediate responses. However, many sperm whales are exposed to just such noises as a result of heavy seismic exploration off the mouth of the Mississippi River, and they continue to inhabit this area. What can account for this? Is it that these signals do not bother the animals or that they are so motivated to stay that they are willing to put up with the exposure?

THE CURRENT REGULATORY ENVIRONMENT IN THE GULF OF MEXICO

The regulatory situation in the Gulf of Mexico is unlike that of anywhere else in United States. Based on 1976 EIS and 1984 EA, a Categorical Exclusion (CE) has been granted for all seismic activities in Gulf of Mexico, with no mitigation (MMS 1999). Under this exclusion, those in the seismic exploration industry are free to shoot when and where they want without consideration of the effects on marine mammals. The Minerals Management Service (MMS) has undertaken a series of reviews of the current regulatory environment in the Gulf. MMS conducted an internal review and concluded that some seismic activities now listed under the CE should be evaluated under an EA to “verify that new technology or environmental information has not altered 1984 determinations” (MMS 1999). There is a pressing need to know direct, indirect, and cumulative effects of seismic exploration signals on marine mammals. Their significance and degree to which these effects are controversial bear on whether another categorical exclusion is granted or an IS is required.

When considering seismic activity in the Central and Western Planning Areas of the Gulf of Mexico in 1997 and 1998, the MMS concluded that the available information was insufficient to be confident that seismic activities would not collectively have significant, adverse, long-term effects on the size or productivity of any marine mammal species or population. The explicit concern was adverse effects that might occur from repeated disturbances of vital functions such as feeding, breeding, and nursing. It is worth noting that a CE does not automatically mitigate a take of marine mammals. Further, a take of endangered species (such as the sperm whale) is prohibited. For small take exclusions, as granted for example in Alaska, the take must be so small or unimportant to warrant little attention.

The Marine Mammal Commission (MMC) in its 1998 Annual Report described the magnitude of the problems with offshore oil development in the Gulf relative to cetaceans (MMC 1999). It noted that an average of three to four seismic surveys are conducted every day in the northern Gulf of Mexico. It would be safe to say that seismic signals, at some level, would be continuously audible to any sperm whales in that area. Additionally, there are 1,000 boat trips, and 2,000 helicopter flights per day. There are also 100 exploratory and development wells drilled every year-- many now in deeper waters. The Commission described particular research needs, including determining whether and how the distribution, abundance or productivity of any resident species or population may have been affected by the seismic sound field.

Categorical Exclusions and other management tools can be maintained using mitigation techniques. At worst, seismic signals can injure animals. Therefore, the minimum goal is to prevent either permanent or temporary hearing damage. Developing standard procedures includes descriptions of zones of influence and soft starts (ramp-up of signals). The High Energy Seismic Survey (HESS) team, under contract with MMS, has described two zones of influence, a 180 dB isopleth-safety zone against hearing damage and 140 dB Isopleth-zone of potential harassment.

THE BIOACOUSTICS OF THE INTERACTION

The interplay of an animal's auditory sensitivity, behavior and motivation relative to a seismic signal's characteristics will determine the form and magnitude of its response. The auditory thresholds have been described for a few small odontocetes (reviewed in Au 1993). A generalized dolphin audiogram is presented in Figure 24. The upper thresholds are between 100-150 kHz, with little sensitivity below 100 Hz. Peak sensitivity is typically between 20-80 kHz. Superimposed on this audiogram are the spectra of their echolocation pulses and their whistles. Less is known about the hearing of larger cetaceans. A hypothesized sperm whale audiogram is presented in Figure 25, along with a spectrum of their pulses. The upper threshold is surmised to be at least an octave above the highest signals in their pulses, while the lower sensitivities are thought to be a product of the animal's overall larger size. Finally, a spectrum of a seismic pulse is overlaid on this hypothesized audiogram, illustrating that the entire signal is likely to be audible to the whale.

Assuming that an animal perceives a signal, its motivation to response may be highly variable. For example, if it is migrating through an area ensonified by seismics, on the way to mating or calving grounds, it may be more or less tolerant than if it were feeding in the area. The importance of its own signals may bear on this tolerance range. If, for example, it is trying to communicate with conspecifics, then the masking effects of a seismic signal, even at relatively low amplitude levels, may prompt a response. To complicate matters further, a lack of apparent response as measured, for example, by the animal' s not leaving an area, may provide no evidence that noise exposure is increasing stress, which in turn may reduce the species' overall fitness through reduced reproductive output. Such a response would only be evident through long-term studies.

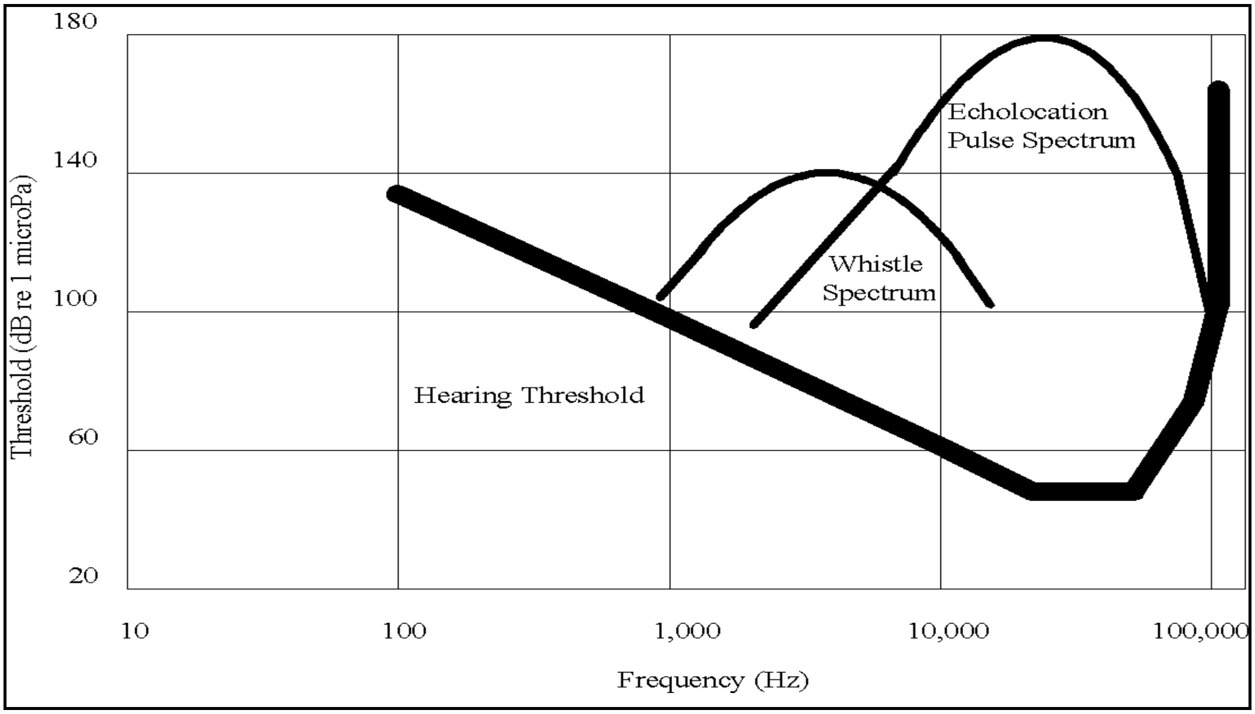

Figure 24. Generalized dolphin hearing threshold, with the spectra of their echolocation pulses and whistles.

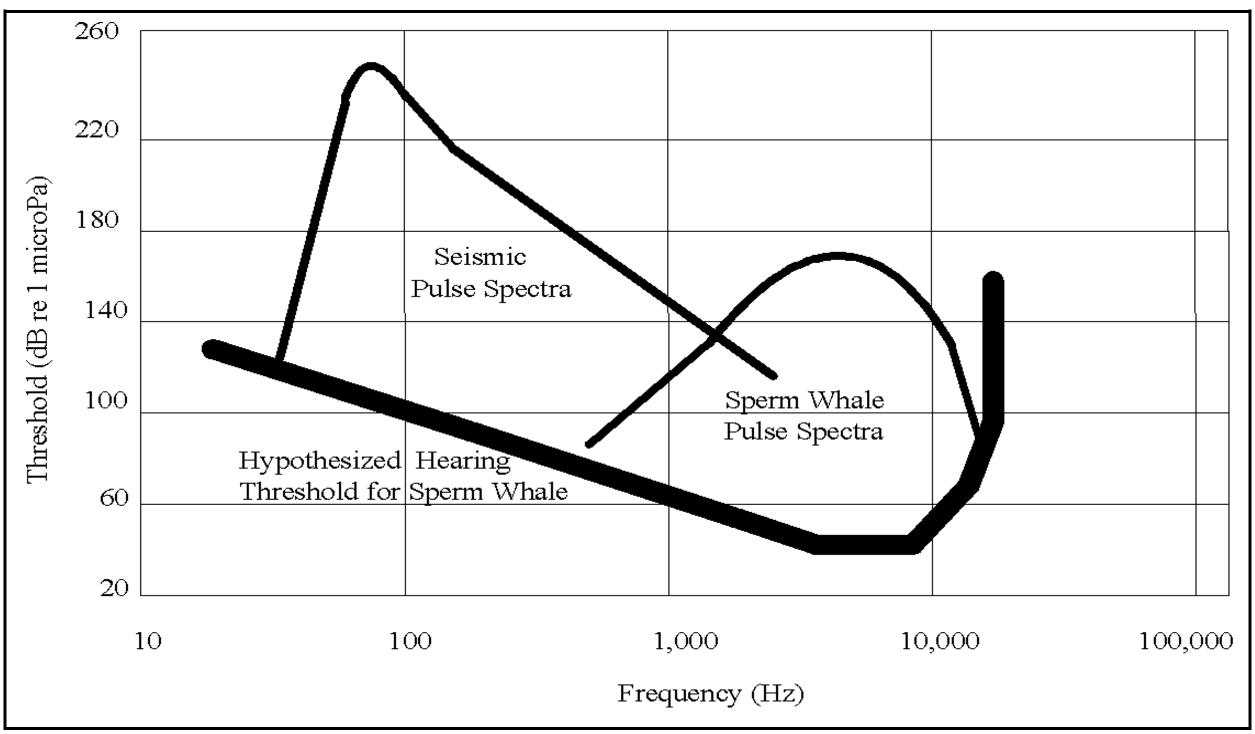

Figure 25. Hypothesized sperm whale hearing threshold, with spectra of their pulses and seismic exploration pulses.

GULFCET FINDINGS

The GulfCet program has gone a long way in determining the distribution and abundance of cetaceans in the Gulf of Mexico. The MMS reports from this program provide detailed maps indicating the distributions of the many species found in the Gulf (Norris et al. 1996). Three aspects of the Gulf's cetacean community bear on the effects of seismic exploration signals: there is a large and diverse community of dolphins, with approximately 14 species and more than 50,000 individuals; a large and stable population of sperm whales in the northern Gulf, some apparently resident off the mouth of the Mississippi River; and finally, there are very few baleen whales, probably less than 100 in the entire northern Gulf.

The large community of dolphins is likely to be relatively insensitive to seismic signals, and their exposure is probably not significant. The opposite, however, is the situation for the larger species, the sperm whale and baleen whales. These species are likely to be highly sensitive to acoustic signals in the frequencies of the seismic exploration signals. These are the species, all endangered, that are most likely to be affected by seismic signals and should be the focus of future research.

Changes in sighting frequency relative to seismics have been studied by Ms. Shannon Rankin (Rankin 1999). Relative intensity of seismic signals was estimated from the signal-to-noise ratio (signal intensity in decibels above ambient). Signal-to-noise measurements were divided into three categories: 0 dB (no seismic signals), 0-12 dB, and >12 dB above ambient. Additionally, hydrographic data were analyzed for potential interdependencies between hydrographic features, seismic exploration and presence of cetaceans. For GulfCet I, hydrographic features were defined by sea surface height measured by satellite altimetry. For GulfCet II, major hydrographic features were determined by shipboard CTD and XBT data which was then used to compute dynamic sea surface height. Five hydrographic regions were defined: cyclone, anticyclone, periphery of the eddy, confluence zone, and “other” areas outside these defined features.

Over 514 hours of “on effort” recordings covering approximately 6,819 km of survey effort were used. A total of 108 hours, or 21% of the total time, contained sounds associated with seismic exploration. The percent time with seismic exploration sounds was 10% for GulfCet I and 34% for GulfCet II. The final cruise of GulfCet II had the greatest percentage of seismic exploration sounds, with pulses present 50% of the time. These sounds were not uniformly distributed in the study area, but were concentrated in areas on the upper and mid-continental slope.

There was no significant difference between the overall sighting rate and the sound level when tested for each of the hydrographic regions. Distributions of two species were additionally examined. The sperm whale sighting rate did not differ significantly between the different sound levels for any of the hydrographic features. The sighting rate of the pantropical spotted dolphin was found to be significantly higher for the >12 dB areas within the hydrographic feature defined as “other” ($\chi 2 = 10.26$, $p = .005$). The sighting frequencies for the remaining hydrographic features did not differ significantly by sound level.

The influence of the scale of observation is important when describing the reaction of animals to noise. There are a number of alternative explanations for the observed distributions that lead to the finding of no significant change in cetacean sighting rate relative to noise exposure, even controlling for hydrographic features. It is possible that the observed cetacean distributions may be due to displacement of cetaceans away from the sound source and, at least sometimes, towards our survey vessel (Figure 26). This displacement may lead to an artificially increased sighting rate, which is opposite of the expected distribution if the animals are negatively influenced by the seismic signals. However, if the cetacean survey vessel was close to the seismic survey vessel, in response to the same flight of animals away from the perturbation, sighting rates would be lower. Lastly, if the animals had responded to the presence of the seismic signal and fled before the cetacean survey vessel had entered into the area, there also would be a decreased sighting rate. Recommendations for appropriate research are made below.

Seismic exploration signals were, as described above, encountered very often during GulfCet cruises. Most signals were of a relatively standard form, with the main energy of the pulse between 100-900 Hz, with one of two echoes, typically below 100 Hz. On a number of occasions, we encountered other signals broadcast from seismic survey vessels. This included a loud seismic shock centered at 2.5 kHz, with little energy below 1 kHz (Figure 27). This figure displays sperm whale pulses as well as three seismic pulses; first the 2.5 kHz pulse, then a more typical seismic pulse below 1 kHz, and finally an echo. This first pulse has the same frequency content of a sperm whale. On other occasions we recorded relatively high frequency pulses, which were apparently produced by transducers placed on the seismic arrays to determine their precise location. I'm told that the array location system that we recorded is no longer in service, but that higher frequency systems, centered between 25-45 kHz are now being used. These signals would be very audible to dolphins.

RECOMMENDATIONS FOR FUTURE RESEARCH

It is appropriate, after eight years of research on these matters, to make recommendations for future research and information needs.

A. Disturbance Responses of Sperm Whales to Seismic Exploration Signals
   1. Before, during, and after study of responses of sperm whales to seismics using seismic vessel and marine mammal survey vessels
   2. Telemeter whales to record received levels and incidence of exposure
   3. Monitor noise levels using buoys
B. Behavior study of sperm whales off the mouth of the Mississippi River. Long-term study of the resident animals, using oil platforms and sailboats. These studies could be low cost and would determine how a known group of animals are responding to seismic exploration.
C Maintenance of centralized data base of seismic exploration activity, with spectra of signals, cruise plot
D. Retrospective analysis of GulfCet data relative to known positions of seismic vessels.

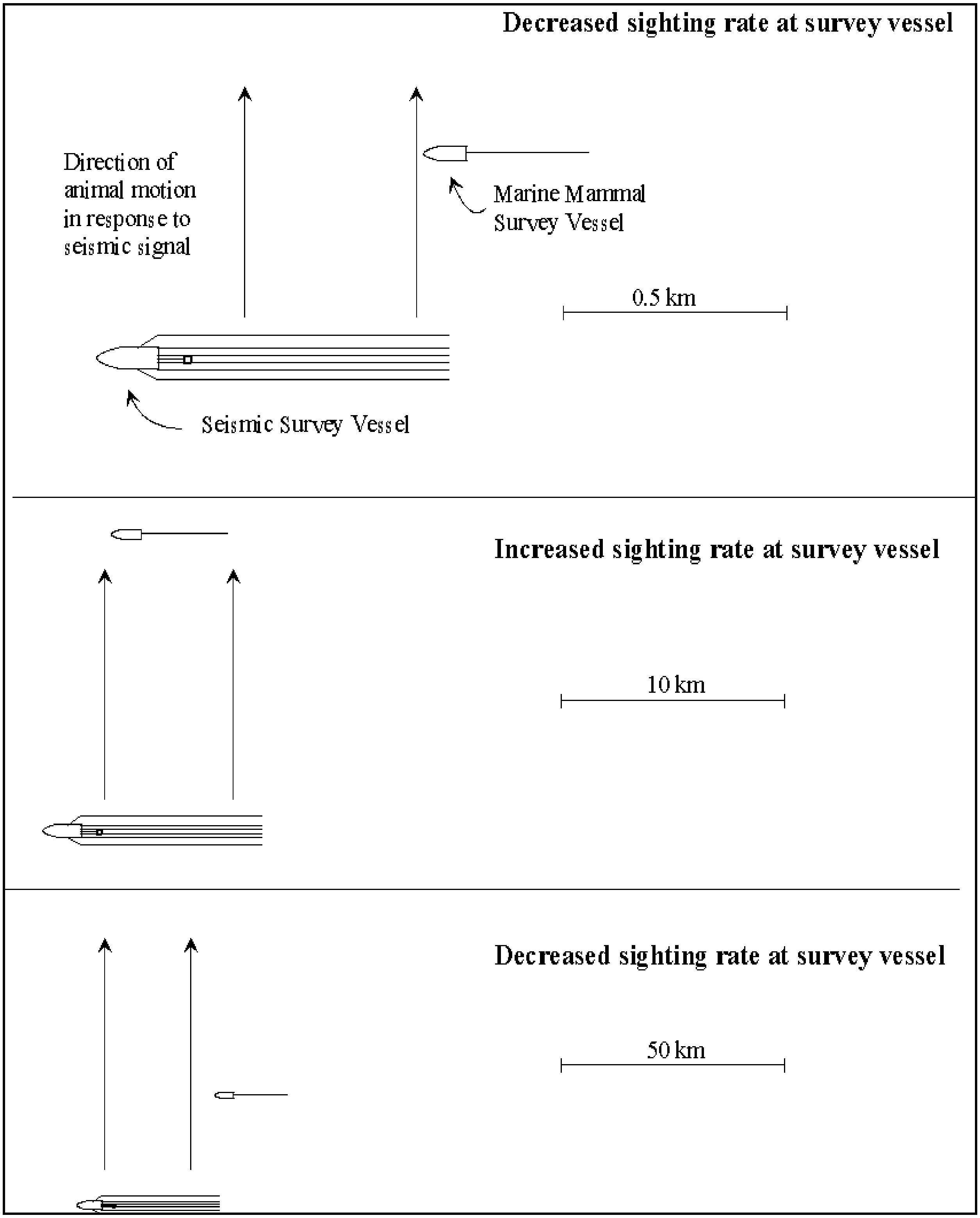

Figure 26. The influence of scale on rate of dolphin encounters relative to seismic signals. The rate should vary according to the scale of investigation, with decreased sighting rate at low and high scales, but increased rate at intermediary scales.

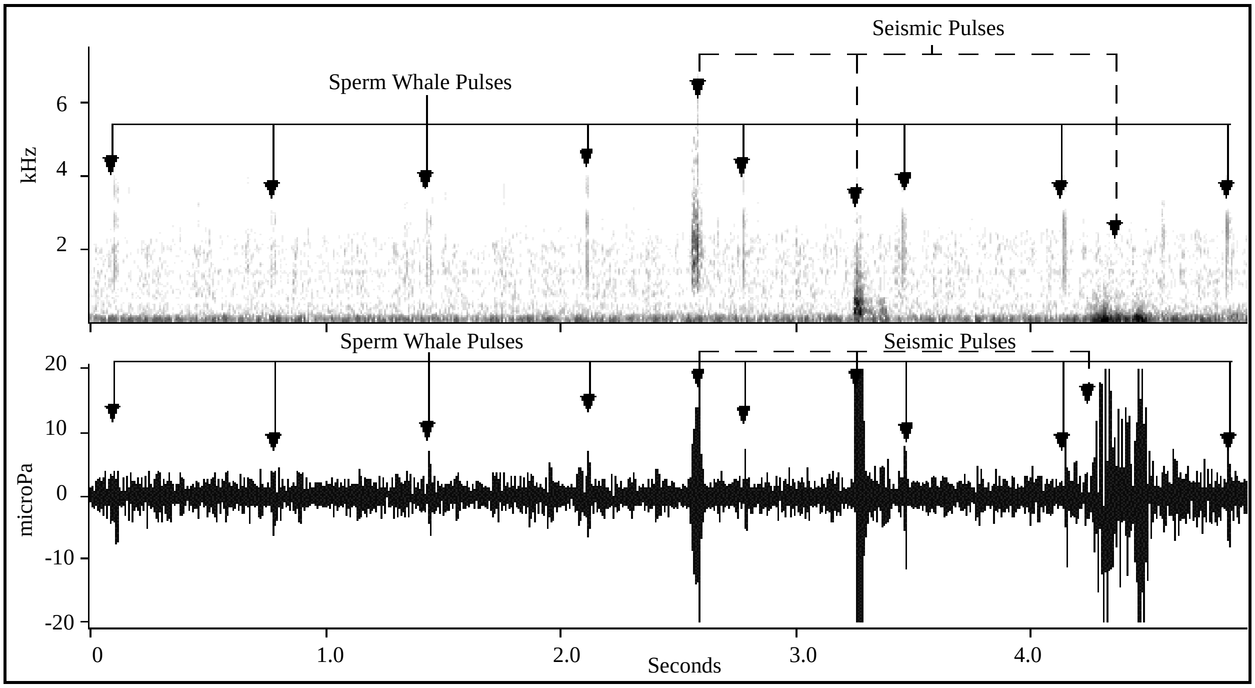

Figure 27. Spectrogram (top) and waveform (bottom) illustrating sperm whale pulses and two forms of seismic signals. The spectrogram displays frequency (y-axis) as a function of time (x-axis) with increased darkness indicating increased amplitude. The waveform displays amplitude over time. Eight sperm whale pulses are indicated, with center frequency at approximately 2.5 kHz. The first seismic pulse is also centered at 2.5 kHz, with little energy below 1 kHz. The second pulse is centered at 900 Hz. The final pulse, centered at less than 100 Hz, is an echo.

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HUMAN ACTIVITIES AND NATURAL EVENTS: IMPACTS ON GULF OF MEXICO SEA TURTLES

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INTRODUCTION

Nearly ten years ago Michael J. Weber was asked to present a similar review of the general situation for sea turtles in the Gulf of Mexico (Weber 1990). He did a very good and very thorough job of outlining the diverse concerns of scientists, conservationists and policy people regarding these endangered and threatened species. I urge you to refer back to that important paper, as well as to a more recent review by Lutcavage and co-authors (1997) which gives up-to-date detail on human-sea turtle interactions. Regarding sea turtles, it is actually amazing to me how little our primary concerns have changed in the intervening decade. I do think the global concerns for the Gulf of Mexico are changing so my goal today is to suggest how sea turtles may fit into the bigger picture.

At the outset, I should emphasize that we appear to have made some real progress in understanding what we need to do to recover the sea turtles and to protect them in their marine habitats. The biggest single problem for sea turtles then and now, and in fact for the past 50 years has been their accidental capture in trawling gear. The National Research Council report of 1990 made this case very carefully and the biological problem has not really changed that much since then (Magnuson, *et al.* 1990). While the populations are showing some signs of a recovery phase, the problem is that there are still way too many immature and adult sea turtles floating up dead along the coast of the Gulf of Mexico (see others, this report). In addition to the trawling problem, I would now like to list the other impacts that I am aware of in three categories: 1) Human Impacts, 2) Impacts of Unknown Cause and 3) Natural Impacts. Finally, I will attempt to provide some “BOLD OLD”suggestions of how I think we can actually solve the Marine Resource use problems of the Gulf of Mexico.

IMPACTS OF HUMAN ACTIVITIES

Complications of Recovery

The most important human impact is the chance we have to correct our mistakes and help species and habitats to recover. The irony of the apparent recovery of sea turtles is that as the populations do better because of extensive conservation programs, more individual turtles will “get in the way” of shipping, boaters, fishermen, and trawlers and thus be negatively impacted by various human activities. As turtle populations increase, more loggerheads will take up residence on offshore platforms, more adult ridleys will forage in prime shrimping grounds and more juvenile ridleys will attempt to raid the crab traps set in shallow waters or grab the baited fish hooks of sport fishermen. Further confounding the recovery of these species is the fact that human rapid coastal population growth is directly and indirectly competing for much of the same habitat that the turtles need.

Commercial Fishing

Increased effort in trawling for shrimp and fish corresponds well with the decline of the Kemp's ridley (*Lepidochelys kempii*) in the Gulf of Mexico. While it is often stated that egg collecting at the primary nesting beach of Rancho Nuevo in Tamaulipas, Mexico was an important cause for the decline of the species, I do not believe this. In the 1950s fishermen out of Brownsville would routinely catch 50+ turtles per trip, eating a few, selling a few and dumping the dead ones overboard. The earliest records of sea turtle migrations in the Gulf of Mexico were from tag returns from nesters tagged at Rancho Nuevo and trawled up by helpful shrimpers off Louisiana.

Other fishing methods are also of concern. In particular, the longline fishery for billfish and tuna. Since this is usually a deep water fishery, the sea turtles most often impacted are the leatherback (*Dermochelys coriacea*). Recent high levels of stranded dead leatherbacks in the Gulf of Mexico (Shaver pers. comm.) also suggests that their love of jellyfish brings them into shallow water for foraging on wind rows of cabbageheads. I have personally seen many leatherbacks foraging just outside the surf along the south Texas coast in water that could not have been more that four meters deep. I have also seen increasing numbers of butterfly nets in recent years. A concern here is that these shallow working nets will capture the juvenile Kemp's ridleys, which seem to prefer the shallower waters near passes and in the estuaries.

Petrochemical Industry

My feeling is that loggerheads (*Caretta caretta*) and possibly hawksbills (*Eretmochelys imbricata)* in the southern Gulf are actually attracted to hard substrate and that the placement of oil and gas exploration/production platforms and stone jetties in the Gulf of Mexico has actually created habitat for these species. The fact that so many loggerheads use the Flower Gardens Banks supports this natural attraction. What is frustrating is that, despite several years of studies, we still know very little about what these turtles are doing, when they use the platforms, what they eat and what their long term migration patterns are. Rig removals can be a problem for the turtles; however, my impression is that several good protocols have been developed which save turtles each year. The seismic exploration, ship traffic and potential for spills are all serious problems which are more difficult to sort out. Granted, large numbers of animals may not be impacted at this time; however, if the populations are now at 10% of their historical levels, what seems to be a small problem now may be huge as the populations recover. The worst case scenario for sea turtles in the Gulf of Mexico would be major spills near important nesting beaches for hawksbills in Campeche, Mexico; for Kemp's ridleys at Ranch Nuevo, Mexico and Padre Island, Texas and for loggerheads in southwestern Florida and the Chandeleur Islands off Louisiana. The aggregating behaviors seen in sea turtles mating offshore and beach nesting has the low probability potential for a major population disaster such as the 1979 Ixtoc spill which reached Rancho Nuevo and Padre Island with weathered oil. Had the spill been one month earlier, when many more turtles were in the area, it could have been a major disaster for sea turtles, including eggs and adults. Turtles do eat tar balls (which are sometimes naturally occurring) along with lots of plastic and latex, which can kill them. They may also be impacted by floating oil derivatives, especially on nesting beaches and potentially in sub-lethal disease synergisms (see below).

Agricultural and Urban Runoff

Sea turtles naturally live a long time and, except for the juvenile and adult green turtle, are predators. They are known to bioaccumulate DDT and its metabolites DDE and DDD. The concern expressed by Lutcavage *et al.* (1997) is that immune suppression may be occurring and that this could account for increased levels of fibropapilloma disease (see below).

Other Clear Impacts

Several other human related activities are now considered to be modest problems for sea turtles but could develop into much more important concerns as both human and turtle populations increase. In particular, capture in channel dredges, boat strikes and incidental capture by hooks in sport fishing will probably each increase as problems for turtles over time.

IMPACTS OF UNKNOWN CAUSE

Three phenomena have been on the increase which, while not adequately documented to be purely human induced, are more than likely related to the huge growth of human populations in the coastal areas. The first, and the most frightening, is the apparent increase during the 1980s in the debilitating disease known as fibropapillomatosis (George 1997). This disease is probably viral in origin but, despite several years of research, has not been explained. The disease is most prevalent in green sea turtles (*Chelonia mydas*) where it is known as GTFP, but has been described in all species except the leatherback. Interestingly, the disease is not now seen in the northwestern Gulf of Mexico. However, as Bob George states (1997) "Turtles frequenting near-shore waters, areas adjacent to large human populations, and areas with low water turnover, such as lagoons, have a higher incidence of GTFP than individuals in deeper, more remote waters." My concerns are that with rising water temperatures (correlates with increased disease levels) due to global warming and with the rebounding numbers of currently highly dispersed sea turtles, we may see contagious epidemics of this disease developing in the future.

The second concern I have is the extent of the hypoxia/anoxia phenomenon in the northern Gulf of Mexico (Harper 1999). While these have long been known from places like Mobile Bay and Laguna Madre, one can not help but be concerned about their potential impacts on food resources for sea turtles. Indeed, the largest described hypoxic area, which is off western Louisiana, is in the midst of what may be the single most important adult foraging grounds for Kemp's ridleys.

The final area of potential human derived impact is the harmful algal bloom situations where there is evidence of "a disturbing trend of increasing frequency" (Buskey 1999). All three of these poorly defined phenomena seem to me to be symptomatic of a marine stress syndrome, for lack of a better descriptor, which indicates a general degradation of the Gulf of Mexico in a way which has never before been experienced.

NATURAL IMPACTS

Sea turtles are well known to experience cold stunning. They typically attempt to avoid cold water when possible; however when trapped will sometimes appear to hibernate when conditions are right (Moon *et al.* 1997) or sometimes die in a few hours when temperatures go below about 8°C (Spotila 1997). Trapping appears to happen on a fairly regular basis in areas like Laguna Madre and the Indian River of Florida where there are a very limited number of openings to the ocean. Since we have not had a severe cold stunning event in several years, we unfortunately can expect a major kill of sea turtles in the near future.

BOLD OLD RECOMMENDATIONS FOR THE GULF OF MEXICO

My primary concern for the Gulf of Mexico and for sea turtles, after 21 years of observing them, is less for the human impacts that we are clearly able to document and do something about and more for the unknown or poorly understood problems which seem to be increasing in their extent and potential negative consequences. At a Sea Grant sponsored meeting last summer (Sharing Our Gulf: A Challenge for Us All) several of us here and an enthusiastic group from many backgrounds attempted to get a better understanding of what has been done, what is working and what needs to be done. The proceedings of that meeting will be published soon (Owens, *in press*) and I am sharing with you here the "Recommendations and Ideas for the Future" section which were hammered out during the meeting and by a small subset of us who met subsequently to refine the suggestions.

An Education Program

The problem is that we still do not have an ethic of resource husbandry for the Gulf of Mexico. Think of what Smokey the Bear has meant for our forests and you will just scratch the surface of what is envisioned as an intense bilingual education campaign for the U.S., Mexico and Cuba. The consensus of the Sharing Our Gulf meeting was that there is a serious need for the development of new forms of communication across all agency, private sector, user group and country boundaries using and depending on the Gulf of Mexico. Always mentioned was the Gulf of Mexico Program with Sea Grant, M.M.S. and N.O.A.A. as the agencies that will have to provide the leadership and financial resources to get this new education program and highly interactive communication system off the ground. More involvement of the other two countries of the Gulf of Mexico is also seen as essential.

Basic Research

Many of the important questions we are now considering suffer from the fact that so few scientists can get funding to delve into their underlying biology, oceanography and geology of these questions. In my case, just as an example. It has been years, for example, since I have been able to get a basic grant funded to work on sea turtle reproduction. And yet I am continuously being asked about endocrine disruptors when I still know very little about how the real endocrine systems work in sea turtles.

A Marine Preserve System

I suggest using the National Marine Sanctuary Program as a model to establish a set of protected areas which can clearly be identified as essential to the Health of the Gulf of Mexico. In particular, several wetland/estuary areas around the Gulf, the marine areas off Padre Island, the Chandeleur Islands, the Yucatan Peninsula and hard-bottom areas off the Florida west coast would be good places to start.

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REVIEW OF RELATED RESEARCH AND MONITORING PROGRAMS

ROLE OF A NON-GOVERNMENTAL IN GULF PROTECTED SPECIES CONCERNS

Ms. Sharon Young
Humane Society of the United States

Although non-governmental organizations (NGO's) sometimes fund research efforts by non-governmental scientists, the easy description is that it is often our role to make life more difficult for regulators. We use the tools at hand: education, lobbying and litigation to do what our constituents wish us to do, and that is to protect animals and their habitats.

Conservation NGOs regularly argue for use of the precautionary principle when considering what activities may be acceptable. At this juncture, our largest concern is often not what we DO know but what we DON'T know about marine animals and their habitats. There are a number of concerns and research needs that are germane to this workshop:

CRITICAL RESEARCH NEEDS

1. Determining the demographics of bottlenose dolphins, including completing studies to determine stock discreteness
2. Evaluating and improving the Gulf of Mexico Marine Mammal Stranding Network
3. Characterizing and monitoring key components of habitat in the Gulf that affect distribution and may be more vulnerable to disturbance
4. Monitoring of population abundance, distribution, and habitat use
5. Long-term monitoring of levels of environmental contaminants and natural biotoxins and human impacts on populations

At this point, I want to note that when I was preparing for this presentation, I started with a list of my general concerns. The list that I have just presented is a condensation of a list of concerns and research needs that were identified for marine mammals in the proceedings of the August 1989 workshop that was held by MMS in New Orleans. I was chagrined to find that with the exception of number two, the list for 1989 was virtually identical to my concerns in 1999.

I sincerely hope that if we are all back in New Orleans in 2009, significant progress will have been made in addressing gaps in our knowledge and the discussion of this list will be focused on all that we have learned to address the concerns rather than the list being repeated 20 years later with little new information gained.

I want to discuss each of these points more specifically and discuss how we, in the advocacy community can help in gathering information to further our knowledge.

With regard to research need number one, bottlenose dolphins (*Tursiops truncatus*) are among the most commonly stranded animals and appear to be one of the most commonly sighted species in the Gulf. Yet there is on-going controversy about their stock identity. The National Marine Fisheries Service (NMFS) has determined that there are approximately 40 separate stocks of bottlenose dolphins residing in bays, sounds, and estuaries; it also has separate stocks of coastal and offshore dolphins. Many in the scientific community believe that some or all of these population units may not be appropriate. Little research has been funded to answer important questions about stock definition. The Humane Society of the United States (HSUS) is very concerned with the low funding priority this issue has received. We have also expressed consternation that high levels of mortality in commercial fisheries, including deaths in the medhaden purse seines in the Gulf of Mexico have not been reduced, despite requirements of the Marine Mammal Protection Act (MMPA). The HSUS has informed NMFS of its intent to file suit over the failure to address mandatory bycatch reduction, maximum levels of which are determined according to abundance data for specific stocks. Any court ruling would likely expedite research funding to assist in answering these questions of stock identity.

With regard to number two, stranding networks are key to helping collect information on sources of mortality and the animals most likely to be affected. These networks must have adequate funds to enable them to conduct thorough necropsies and tissue analyses to assist in answering many questions relating to stock identity and sources of risk to animal health. Just last week, I provided testimony to Congress in support of a proposed addition to the MMPA that would provide direct grant funds for stranding networks to enhance their response and analytical capabilities. We will continue to advocate for adequate funding for stranding networks.

Research need number three deals with key habitats for marine mammals. It is important that we understand why animals are found where they are found. The GulfCet program has taken some important first steps toward identifying areas of high use and beginning to model their importance. We in the advocacy community have been working hard to obtain priority funding to develop predictive models of animal distribution. Much of our effort has been focused on obtaining funds for modeling right whale distribution on the east coast. We are hopeful that progress in that area will lead to development of software to allow ocean and climatological information and information on geologic and oceanographic features to be used to predict distribution for other species. The success of this modeling is predicated on answering some of questions inherent in the last two bullets on the list.

Since the workshop in 1989, the GulfCet Program has done much to help us to better understand population abundance and distribution in the Gulf of Mexico. It has also helped our awareness of factors that may affect their distribution, such as cold core rings and the Mississippi freshwater plume. Yet reports from this program acknowledge the need for additional studies including expanded use of telemetry, focal studies and combined aerial and shipboard studies to expand our knowledge of the abundance and distribution of marine mammal and turtle species. These studies are also important to establish both a baseline and a long-term monitoring strategy that identifies important habitat for particular segments of the population as they forage, rest, reproduce or transit the Gulf. We can assist these efforts by advocating for on-going surveys and increased funding.

It is number five that is of particular relevance to this workshop. We continue to have only the most rudimentary information on pollutants and naturally occurring biotoxins. Since the 1989 workshop, we have learned more about the impact of some human activities, but we still know little about others.

POSSIBLE SOURCES OF HUMAN IMPACT

- Coastal Development (run-off, marine dumping and dredging)
- Offshore oil and gas development
- Recreational and commercial vessel traffic
- Military exercises and activities
- Commercial fisheries (actual bycatch, ghost gear, resource competition)
- Pollution from oil spills, agricultural run-off, industrial effluent, marine debris
- Live captures for display and research
- Illegal shooting
- Use of explosives to remove offshore structures
- Whale watching and dolphin feeding
- Natural factors such as algal blooms, epizootics, hurricanes, climate change

This last potential impact may not seem to be related to humans; however, some research has indicated that harmful algal blooms may be related to human activities such as aquaculture expansion in concentrated areas. Despite claims to the contrary, even some aspects of climate change appear to result from human activities.

As we examine this list, live captures are one of the only factors whose impact on populations has probably been reduced. As to the others, I suspect that we really know little about the extent of their potential adverse activities but might suspect that for some, the effect may be significant (e.g. fishery-related mortality).

As an advocate for the animal welfare community, I need to know the degree to which an activity may be affecting an animal or a population. If it causes a significantly adverse impact, then I will want to do something about it (more about what I would do later). Determining the impact is not always easy (Figure 28).

Dan Costa presented a paper at the 1997 meeting of the American Fisheries Society, in which he discussed how we can evaluate the impacts of noise. I have adapted it for use in a more general context.

What the law requires may not be adequate. A survey that finds animals of some species in the area does not mean that other more sensitive animals have not been affected and perhaps displaced from former habitat. We know little about the stocks that inhabited the Gulf of Mexico before the advent of offshore oil drilling. Animals that once may have been seen in abundance may now be rare. For example, bottlenose dolphins may be more resistant to a potential adverse impact and still be seen in an area, while animals such as beaked whales and Brydes whales may be more sensitive and may have been displaced.

Determining Impacts on Protected Species

Legal Definitions:

- Definitions of take, harassment, jeopardy, negligible impact
- Threshold of impact is usually observable changes in behavior, abundance or distribution
- Legal thresholds still allow adverse impacts

Biological Definitions:

- Health and stability of populations
- Habitat utilization
- Short term effects (acute)
  - Change in behavior
  - Change in distribution
  - Temporary physiological changes
- Long-Term Effects (chronic):
  - Abandonment of habitat
  - Permanent damage/serious injury
  - Decline in population

Figure 28. Determining impacts on protected species.

Noting that animals continue to feed in the presence of noise does not mean that they are not affected. Animals that are significantly affected at a sub-lethal level may not realize the degree of their incapacitation and its affect on their future survival until it is too late. For example, factory workers have been known to work under unsafe conditions with intense noise that eventually deafens them or breathing contaminants that eventually cause lung cancer, yet in their desire to obtain resources (money) they tolerate the poor conditions and may be unaware of the danger they court until it is too late to reverse the damage. We insist on a precautionary approach to human health. We must approach the health of the ocean ecosystem and its inhabitants with some care as well.

Unfortunately, this approach is rarely taken. In particular, noise proliferates with little concern being raised. Dan Costa of the University of California commented to the 1997 meeting of the American Fisheries Society that the ambient level of sound in oceans of the northern hemisphere has increased 20 decibels in the past 50 years. A Marine Mammal Commission report stated that in 1998 there was an average of three to four seismic surveys in the northern Gulf of Mexico each day and more than 100 exploration and development wells drilled every year. Furthermore, each day there is an average of over 1,000 boat trips and 2,000 helicopter trips to transport personnel and equipment. This activity is a not an insignificant contributor to noise in the ocean.

In their 1998 report to Congress, the Marine Mammal Commission noted that "because exploration and development have been going on in the northern Gulf for 40 years, it is possible that all of the potentially affected marine mammal species have become accustomed to the noise and are no longer affected by it. It is also possible that some or all of the potentially affected species have altered their habitat-use patterns to avoid noisy areas." Further that "such effects could be species-specific, age-specific, or area-specific." The significance of the habitat displacement depends on the productivity and importance of the area from which they have been displaced. As noted above, because we know so little about the importance of particular areas to some or all members of a species or population, we cannot hope to understand the significance of displacing them, if indeed we can even detect that displacement has occurred.

However, because monitoring for the biological evidence that we seek is expensive and difficult, it is often forsaken. Because of the arcane nature of issues like noise pollution, it is difficult for advocates to mount campaigns to heighten awareness or curtail projects that inject more and more noise into the environment.

In considering the impacts of expanded exploration for oil and gas in the Gulf and the demolition of existing structures, it is important that impacts of a single factor be considered in the light of the cumulative impact from other factors. A species or population, such as bottlenose dolphins, may be killed in commercial fisheries, shot for preying on fish near boats, exposed to significant levels of pollutants, disturbed by continual pursuit from whale watch boats, and suffering periodic mass mortality due to harmful algal blooms. If we add to this exposure to increased sound levels that displaces animals into more marginal foraging habitat, disrupts their social behavior or causes a minor but permanent threshold shift in their hearing, we may find that the effect is almost synergistic. Each factor in and of itself may not cause a population level problem, but when added together, the impact may be severe. When it comes to evaluate impacts on endangered species, we must remember that the goal should not be simply to avoid jeopardizing the continued existence of the species (as it stipulates in the Endangered Species Act) but to recover depleted populations to abundance. This is often overlooked.

There are a number of concerns with offshore oil and gas exploration and production that were on the list of possible human impacts. I'm sure that you are all aware of them, but I will briefly re-state them:

- Adverse effects of spills, leaks, and disposal of platform-related debris
- Vessel collisions with marine animals
- Disruption of benthos or suspension of harmful particulate
- Adverse impacts from noise
- The effect of blast trauma on animals
- Changes to ecosystem from erection/demolition of structures
- Ability or inability to monitor impacts of these activities

WHAT IS THE MINERALS MANAGEMENT SERVICE TO DO?

MMS must expand its contributions to funding of projects to monitor populations and effects of its permitted activities. I also believe that it is appropriate to charge beneficiaries of the resource exploitation for the cost of determining the effect of removing the resource. This is often done in other industries. It might be required as a condition of obtaining a lease or permit.

MMS can encourage research and development of less intrusive technology. Perhaps we need to offer incentives to develop new technologies that are quieter and more risk averse by requiring additional research and development as a condition of obtaining a lease. I note that progress in developing technology to significantly reduce emissions in automobiles came only after it was federally mandated, and over the protests of the industry that it was not fiscally feasible.

It is particularly important that the MMS, in conjunction with its partners, undertake monitoring in areas in which there is a proposal to expand activities. Baseline studies of abundance and distribution of protected species and habitat use patterns must be undertaken PRIOR to expansion of exploration, production or demolition. We must also attempt to determine the source and intensity of sounds, and set limits on acceptable levels, locales, or conditions under which sounds may be generated.

MMS must assist in mapping important or high-use habitat areas for marine mammals and turtles and prohibit or severely limit activities in those areas to reduce possible risk. With regard to noise, we must remember that some sounds may affect movements or behavior for several kilometers under the right conditions.

AS AN ADVOCATE, WHAT IS MY ROLE IN THIS PROCESS?

When I am aware of particular needs, I will advocate on behalf of needed funding from Congress. I can help in the development of public or industry awareness programs. I can help make regulators or legislators more sensitive to conservation concerns by lobbying or educating them on behalf of the animals who will be affected. I can become a part of international efforts to provide protection that extends beyond U.S. boundaries—in this case into Mexico and the wider Caribbean. I can provide comments on regulatory or legislative proposals, attempting to highlight missing or important informational needs that should be met. Last, I can sue somebody. Litigation is not the best management tool, but it has become increasingly important in a world of squeaky wheels that beg for grease and it can be used to help me in my role. My role is to protect animals by insuring that there is compliance with protective legislation; and by providing a voice for them when they cannot speak on their own behalf, I can ask that the same precautions we seek for ourselves be extended to them.

MARINE MAMMAL STRANDING NETWORKS AND ENVIRONMENTAL CONTAMINANTS

Dr. Teri Rowles*
Office of Protected Resources
National Marine Fisheries Service

The National Marine Fisheries Service (NMFS) is one of two lead agencies responsible for administering the Marine Mammal Protection Act (MMPA). The Marine Mammal Health and Stranding Response Program (MMHSRP) was formalized by the MMPA Amendments of 1992, and this presentation described not only the Gulf of Mexico component of this program, but also highlighted the need for national and international coordination of stranding network activities.

The MMHSRP goals are (1) to facilitate collection and dissemination of reference data and to assess health trends; (2) to correlate health with available data on physical, chemical, environmental, and biological parameters; and (3) to coordinate effective responses to unusual mortality events. To accomplish these goals, the MMHSRP has five primary components: (1) marine mammal stranding networks; (2) investigation of unusual mortality events; (3) biomonitoring; (4) National Marine Mammal Tissue Bank; and (5) analytical quality assurance.

Through a national coordinator and five regional coordinators (the entire Gulf of Mexico coastline is in the NMFS Southeast Region), NMFS oversees, coordinates, and authorizes stranding response activities, provides training to personnel, and collects data from strandings. To respond to these strandings, volunteer stranding networks have been established in all coastal states. When animals strand dead, samples are collected not only to determine cause of death, but also to provide data on biology and health for management activities. Research topics may include the following: life history parameters, general health, disease trends, and the effects of chemical contaminants, as well as other human activities on these animal populations. The Southeast Fisheries Science Center has a regional stranding database that has near-real time reporting. This data may then be transferred to the national stranding database and for cetaceans to the Marine Mammal Event database at the Smithsonian Institute, National Museum of Natural History.

The network responded to approximately 33,000 strandings around the nation from 1990-1998. Approximately two-thirds of these strandings consist of seals and sea lions, with cetaceans making up the remainder. During 1993-1998, there were 2,500 cetacean strandings in the Gulf of Mexico; these included two unusual mortality events for cetaceans.

The 1992 amendments also established the Working Group on Unusual Marine Mammal Mortality Events, which uses criteria for determining when an unusual mortality event is occurring and then directs responses to such events. Once an event has been designated as "unusual," the MMPA

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*Roger Gentry made this presentation for Dr. Rowles, who was attending a Congressional hearing on the Marine Mammal Rescue Assistance Act, a bill to provide a funding mechanism for eligible stranding programs.

directs NMFS to inform the stranding network of that determination and to designate an onsite coordinator. Once this has been done, there is a sequence of events that may take place, including the following: stepped-up response to the event; increased monitoring and data collection; increased communication with the National Stranding Network Coordinator; continued consultation with the Working Group; increased collaboration with other groups and agencies; and enhanced monitoring and data collection efforts. There have been 15 mortality events designated as “unusual” since 1990; four occurring in the Gulf of Mexico (1990, 1992, 1993-1994, and 1996).

In recent years, high concentrations of potentially toxic substances in marine mammals have been documented, both natural (e.g., biotoxins) and manmade (e.g., PCBs and pesticides). Harmful algal blooms (HABs), which produce biotoxins, are of increasing interest as there have been new reports of biotoxin related deaths in marine mammals. There seems to be an increased impact of these events on marine mammals since 1972, but it is not clear whether this is truly the case or simply a reflection of better reporting of stranding events. HABs have been implicated in strandings of pinnipeds on the west coast of the United States, humpback whales in the northeastern United States, manatees in Florida, and the Mediterranean monk seal in Mauritania. Relative to the Gulf of Mexico, the most significant biotoxin relative to risks to marine mammals has been brevetoxin, and considerable work still needs to be done to better assess the risk and to better detect the exposure, levels and impacts in marine mammals.

The biomonitoring component of the MMHSRP was established to develop baseline health data, monitor trends, and investigate impacts of disease, natural toxins, and pollution on marine mammal populations. The biomonitoring component encompasses (1) biomonitoring; (2) case-specific investigations; and (3) research and development.

Biomonitoring in the Gulf of Mexico has principally been done through contaminant and health studies at Mote Marine Laboratory, Dolphin Biological Research Institute, Southeast Fisheries Science Center, and the Texas Marine Mammal Stranding Network. Through these programs delphinids in the offshore northern Gulf were biopsied, bottlenose dolphins from Florida and Texas strandings were monitored for contaminants and health, rough toothed dolphins from two mass strandings were examined for health and contaminant levels, and live captures have been sampled for organic pollutants, heavy metals and disease in two principal locations (Matagorda Bay and Sarasota Bay). Analyses of tissues from delphinids in both coastal and pelagic areas show that all the animals had been exposed to persistent organic pollutants and to heavy metals; however, there are regional, species, and trophic level differences in the types and levels of pollutants. Future studies will further address the potential risks of these exposures to marine mammal populations.

Future enhancements to the Southeast Region Stranding Network include the preparation of new guidelines for the Letters of Authority (which grant the stranding networks the authority to respond to stranding events), increased training, and a web-based or net-based stranding database. NMFS has also been working to enhance coordination with international stranding networks in Latin America, particularly with the Mexico stranding network, to better coordinate the greater Gulf of Mexico area assessing stranding rates and health in species and individuals which may be shared between the two countries. NMFS has scheduled stranding training workshops in various parts of Latin America. NMFS is seeking matching funds to help with this coordination to attempt to close the gap of stranding information for the Gulf of Mexico coastline extending from the Yucatan Peninsula of Mexico to Brownsville, Texas.

Dr. Teri Rowles is with the NMFS Marine Mammal Health and Stranding Response Program. She has been Program Coordinator since 1995.

NATIONAL OCEAN SERVICE AND SEA TURTLES: HABITAT SUITABILITY MODELING

Mr. Michael S. Coyne
Biogeography Program
Center for Coastal Monitoring and Assessment
National Ocean Service
Silver Spring, Maryland

The objectives of this workshop are to (1) review the state of knowledge of marine species (marine mammals and sea turtles) in the Gulf of Mexico protected under the Endangered Species Act and Marine Mammal Protection Act; (2) identify critical information needs for the Minerals Management Service (MMS); and (3) facilitate coordination among various funding agencies.

Within these guidelines, the emphasis of this paper is to review the National Ocean Services' (NOS) involvement in sea turtle research and, in particular, to describe the Biogeography Program's activities as they may help MMS meet the above objectives. Previous workshops have commented on the need to develop a predictive model to quantitatively assess the impact of industrial activities on sea turtle populations in the Northern Gulf (Bjorndal and Bolten 1990). Therefore, a large portion of this paper describes the Biogeography Program's expertise in habitat suitability modeling (HSM), which offers an excellent opportunity for meeting this need.

NOS ACTIVITIES

Historically NOS has played a limited role in sea turtle research and management, although several products have been used extensively by other state and federal agencies and departments. Earliest efforts have included the development of such products as the Gulf of Mexico Coastal and Ocean Zones Strategic Assessment: Data Atlas (NOAA 1985) which provided descriptions and distributions of loggerhead and Kemp's ridley sea turtles, as well as several marine mammal species.

More recent sea turtle work has been carried out within the National Marine Sanctuaries Program of NOS. These efforts have primarily focused upon the loggerhead sea turtle and included tagging and tracking of turtles that utilize Gray's Reef off the coast of Georgia and the Flower Garden Banks off the coast of Texas (Mitchell, in press).

Finally, the Center for Coastal Fisheries and Habitat Research in Beaufort, North Carolina, has recently reorganized into the NOS organization. Previously a part of the National Marine Fisheries Service (NMFS), the Beaufort laboratory has conducted and continues to carry out research in cooperation with NMFS on sea turtles in the Pamlico-Albemarle Estuarine Complex. These efforts have included work on juvenile loggerhead, green, and Kemp's ridley sea turtles. Most notable is an ongoing cooperative effort with local pound fishermen to establish an index-abundance-area to monitor, assess and predict the status of and impacts to sea turtles and their ecosystems (Epperly *et al., in press*). Additional work has involved the treatment and release of cold-stunned sea turtles and the use of NOAA's CoastWatch sea surface temperature (SST) imagery to help protect overwintering sea turtles during fishing activities off North Carolina and Virginia. A final rule under the Endangered Species Act reduces the area within which Turtle Excluder Devices are required during January 15 - March 15 (FR Vol. 61 Num. 16, pp1846-8). This imagery is being used by other agencies and aquariums to help determine optimal locations along the east coast for returning rehabilitated turtles to the sea.

BIOGEOGRAPHY PROGRAM ACTIVITIES

NOS' Biogeography Program is part of the Center for Coastal Monitoring and Assessment within the Centers for Coastal Ocean Science. Historically, the Biogeography Program has had little involvement in sea turtle research or management activities. However, recent development of cutting-edge GIS technologies and modeling techniques have placed the program in a position well suited to address many issues related to protected species.

A goal of the Biogeography Program is to develop knowledge of living marine resource distributions and ecology throughout the nation's marine, coastal and estuarine environments to provide managers with an improved ecosystem basis for making decisions. This effort has led to the development of a suite of products which use a continuum of approaches to define bio-physical relationships which differ in data content, complexity, and analytical structure (Figure 29).

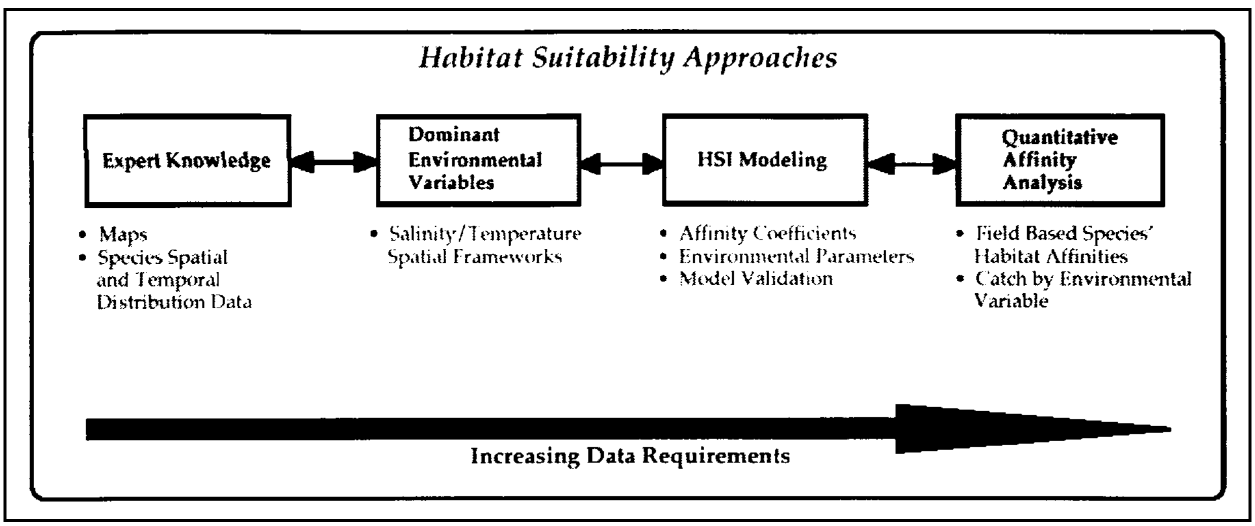

Figure 29. Four approaches to coupling species distribution and habitat.

NOAA's Biogeography Program was a partner with MMS in developing the Gulfwide Information System (GWIS). The objective of GWIS was to develop an authoritative database to be used by MMS, industry and other regulatory and resource protection agencies for oil spill planning and response activities. Environmental sensitivity indices and biogeographic characterizations were developed for invertebrate, fish, bird and sea turtle species. NOAA's efforts included (1) digital integration of NOAA's Estuarine Living Marine Resources data (ELMR); (2) digital update of selected coastal/marine fishes in the Gulf of Mexico; and (3) a development of a desktop GIS system to organize and analyze the GWIS database.

NOAA's Biogeography Program also has worked cooperatively with NMFS and the regional Fishery Management Councils to meet Essential Fish Habitat requirements of the reauthorized Magnuson-Stevens Fisheries Conservation and Management Act. Products delivered to the councils included maps and supporting data with spatial and temporal distribution and abundance of high-priority, managed species.

EFH work has helped identify critical information needs, particularly in the Caribbean, and has catalyzed an effort to identify and map coral reef and other shallow water habitats in the Caribbean using remote sensing technologies. A Memorandum of Understanding has been developed with the National Park Service to utilize Buck Island National Monument (BUNM) in St. Croix as a test site for the development of coral reef habitat classification scheme for Puerto Rico and the U.S. Virgin Islands. Plans are currently under development to extend this effort to U.S. possessions in the Pacific.

Specific habitat classification efforts at BUNM include a study of resident juvenile hawksbill sea turtles in relation to distribution of prey. Zoanthids have been identified as a major dietary component of BUNM hawksbills, and as such, the spatial and temporal distribution and abundance of both organisms is being characterized. Additional cooperation with the NPS has led to advanced GIS support for ongoing sea turtle satellite telemetry operations (Hillis-Starr *et al., in press*). New approaches to spatial analysis of sea turtle tracking data are being developed beyond traditional methods. Efforts are being made to explore new ways of displaying these data and to associate sea turtle tracks with various habitat and environmental parameters.

HABITAT SUITABILITY MODELING

As a tool, habitat suitability modeling (HSM) has a lot to offer in terms of research and management decision-making. The underlying approach was introduced by the U.S. Fish and Wildlife Service's Habitat Evaluation Procedures Program, whereby models resulted in a numerical index of habitat suitability. Models were based on the assumption that a positive relationship exists between the index and a habitat's carrying capacity for a given species (Schamberger *et al.* 1982). Our models depart from the USFWS methods by incorporating a spatial component to produce a view of the relative suitability of locations in geographic space through time. The intent was to develop a simple spatial model using GIS technology that offers estuarine resource managers a habitat assessment capability that can be applied to a wide range of marine species.

Model complexity and structure can vary considerably depending upon data availability and the questions being asked (Figure 30). The simplest models are based upon expert knowledge of a species and its habitat to create simple polygonal maps of spatial and temporal distribution. Slightly more complex models look at species distribution based upon a dominant environmental variable, such as salinity (Bulger *et al.* 1993; Christensen *et al.* 1997). Habitat suitability index modeling combines the suitability of several environmental variables using a simple equation, such as a

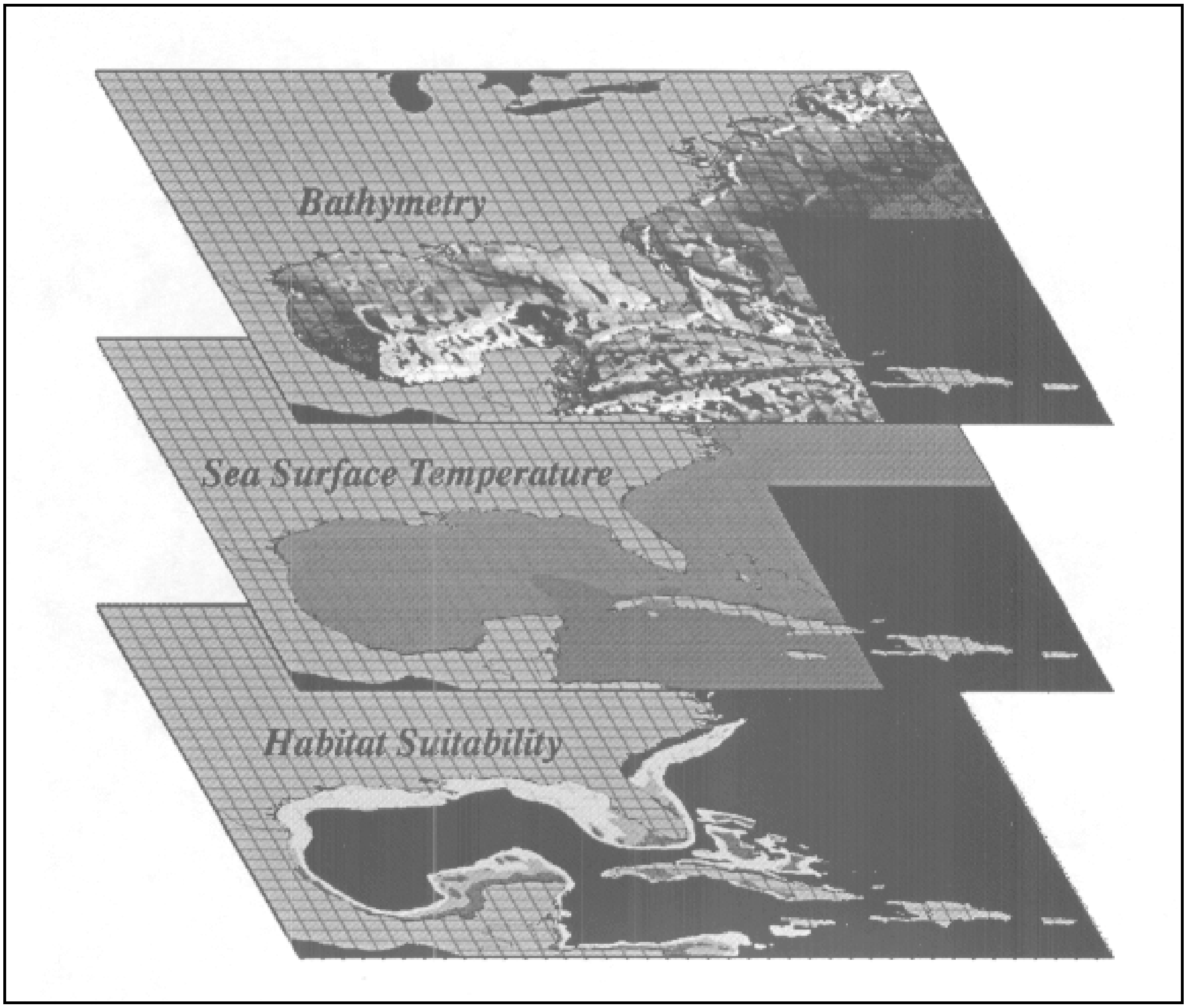

Figure 30. Hypothetical habitat suitability model for Kemp's ridley sea turtles. Predicts potential winter distribution.

geometric mean (Rubec *et al.* 1998; Rubec *et al.* 1999; Coyne *et al., in press*). Finally, several habitat layers can be combined using a multivariate equation describing a species' relationship to those variables.

CONCLUSIONS

NOS' Biogeography Program's goal to develop knowledge of living marine resource distributions and ecology coincide with MMS' objectives as they relate to protected species. In particular, the Biogeography Program's experience with habitat suitability modeling can serve as an invaluable tool. HSM is well-suited to address the need to develop predictive models to quantitatively assess the impact of industrial activities on sea turtle populations in the Northern Gulf of Mexico.

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Michael Coyne is a marine biologist with the National Ocean Service's Biogeography Program. He received his graduate training from Texas A&M University studying feeding ecology in green sea turtles and sex ratio and population dynamics of the Kemp's ridley sea turtle. Current responsibilities include the development of distribution and abundance models for the nation's coastal ocean resources, primarily utilizing GIS technology. He is also online coordinator for the internationally distributed *Marine Turtle Newsletter*.

SEA TURTLES AND THE NATIONAL MARINE FISHERIES SERVICE

Ms. Sheryan Epperly
National Marine Fisheries Service

Ms. Epperly's presentation included the following slides.

**Southeast Fisheries Science Center
Sea Turtle Program**

- **Recovery and Conservation Research and Development**
- **Stock Assessment and Status Review**
- **Mortality Estimation**
- **Mortality (Bycatch) Reduction**
- **Habitat**
- **Health**

Recovery and Conservation Research and Development

- **ID/Distribution of Stocks**
  - **mtDNA analysis of stranded loggerheads and foraging ground animals (NMFS, Univ. of Florida, & Florida DEP)**
  - **nuclear DNA primer development, description of Atlantic loggerhead rookeries, and analysis of NC foraging ground animals (Univ. of Florida)**
  - **Caribbean hawksbill distribution and movements (NMFS & Mexico, Caribbean nations)**

Recovery and Conservation Research and Development

- **Population Trend Information**
  - **Enhanced nesting surveys at Rancho Nuevo for Kemp's ridleys (USFWS, NMFS, Gladys Porter Zoo, & Mexico)**
  - **In-water index studies**
    - **Pamlico-Albemarle Estuarine Complex, N.C. (NMFS)**
    - **s.e. U.S. (FY 2000) (NMFS & S.C.)**
    - **St. Lucie, Fla. (Florida Power & Light Co.)**
    - **Cedar Key, Fla. (NMFS & Univ. of Florida)**

Recovery and Conservation Research and Development

- **Other Model Input Data**
  - **Age Estimation (NMFS & Duke Univ. Marine Lab)**
  - **Mass tagging of hatchling Kemp's ridleys to estimate pelagic stage growth, duration, and mortality (NMFS & Mexico)**
  - **Cooperative Marine Turtle Tagging Program (NMFS, Univ. of Florida, many states and universities, observer programs, community organizations, etc.)**

Stock Assessment and Status Reviews

- **Turtle Expert Working Group (NMFS, USFWS, Florida, Georgia, South Carolina, industry, and CMC)**
  - **Kemp's ridley**
  - **Loggerhead**
- **Sea Turtle Status Review Working Group**
  - **Kemp's ridley**
  - **Leatherback**

Mortality Estimation

- **Incidental Capture by Recreational Fishermen (NMFS and the MRFSS: Gulf and Atlantic Coast states & Texas)**
- **STSSN (all Atlantic Coast states, Univ. Alabama, Gulf Islands National Seashore, Univ. Texas, Padre Island National Seashore, McNeese State Univ., Aquarium of the Americas, and untold number of volunteers)**
- **Commercial Fishery Observer Programs**
  - **longlines, gillnets (Mid-Atl. coastal and shark driftnet), trawlers in Mid-Atl. (flynets and flounder trawls)**

Mortality (By-Catch) Reduction

- **TED Development (and observers) for Shrimp, Flounder, and Flynet Trawls (NMFS & industry)**
- **Captive Rearing for TED Testing (NMFS)**
- **Eastern Atlantic Longline Experiment (NMFS, Univ. Florida, Azores, & industry)**
- **Monitoring AVHRR Imagery to Regulate the Use of TEDs in the Winter Trawl Fishery (NMFS & NOS' CoastWatch)**
- **Platform Removal Surveys (NMFS & MMS)**

Habitat

- **In-Water Surveys for Green and Hawksbill Turtles**
  - **Puerto Rico (NMFS, P.R., USFWS, & Chelonia, Inc.)**
  - **U.S. Virgin Islands (FY2000?) (USVI, USFWS)**
- **Designation of Critical Habitat**
  - **green turtles: Culebra, P.R.**
  - **hawksbills: Mona and Monita Islands, P.R.**
- **South Florida Ecocystems**

Health

- **Health Assessment Workshops (NMFS, NOS Charleston Lab, academia, private industry veterinarians, etc.)**
- **Sea Turtle Anatomy Manual (Florida Atlantic University)**
- **Sea Turtle Necropsy Manual (FY2000?)**
- **STSSN**
- **Fibropapilloma (lead is SWFSC; USFWS & many academic collaborators)**
- **Forensics (NOS Charleston Lab & STSSN)**

Sheryan Epperly completed her graduate work in fisheries (biochemical, meristic, and morphometric identification of subpopulations of Atlantic menhaden) at the University of South Florida and Duke University while employed as a student with the National Marine Fisheries Service. She worked for the State of North Carolina for five years on estuarine and reef fish before returning to the NMFS Beaufort Laboratory to work on ageing of juvenile Atlantic menhaden. She has numerous papers published on her fisheries research. In 1988 she was assigned to begin a sea turtle research project in North Carolina and since then has published seven peer review papers, seven non-peer reviewed papers, and coauthored 23 presentations at scientific meetings on sea turtles. A year ago she moved from Beaufort to the Southeast Fisheries Science Center in Miami where she is the team leader for the Center's Sea Turtle Program, coordinating research activities within and outside the agency.

U.S. GEOLOGICAL SURVEY/NATIONAL PARK SERVICE KEMP'S RIDLEY SEA TURTLE RESEARCH AND MONITORING PROGRAMS IN TEXAS

Dr. Donna J. Shaver
U.S. Geological Survey
Biological Resources Division
Columbia Environmental Research Center
Padre Island National Seashore

Over the last 20 years, the U.S. Geological Survey (USGS) and National Park Service (NPS) have conducted many sea turtle research, monitoring, and conservation projects on the Texas coast. These efforts have involved a variety of techniques for the five sea turtle species that occur in the northwestern Gulf of Mexico. However, most work has focused on Kemp's ridley (*Lepidochelys kempii*), the most critically endangered sea turtle species in the world.

EXPERIMENTAL IMPRINTING

For two decades, a project has been underway to increase Kemp's ridley nesting at Padre Island National Seashore (PAIS), Texas. Most Kemp's ridley sea turtles nest near the village of Rancho Nuevo, Tamaulipas, Mexico. In 1978, an experimental, bi-national project, involving the NPS, National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), Texas Parks and Wildlife Department, and Mexico's Instituto Nacional de la Pesca was undertaken to establish a secondary nesting colony of Kemp's ridley sea turtles at PAIS, where nesting had been documented historically (Fletcher 1982; Shaver 1987, 1990, 1992). Establishing a secondary nesting colony in the United States offered protection for the species, in case of an environmental or political catastrophe at the primary nesting area in Mexico (Shaver 1990; USFWS and NMFS 1992).

From 1978 through 1988, approximately 2,000 Kemp's ridley eggs were collected each year at Rancho Nuevo and incubated at PAIS (Shaver 1990). Hatchlings were experimentally imprinted to the beach at PAIS in hopes that they would someday return to south Texas to nest. Each year, turtles from this project were reared in captivity for their first 9-11 months of life (head-started), tagged, and released into the Gulf of Mexico and adjacent bays (Caillouet *et al.* 1995).

NEST DETECTION AND EGG INCUBATION

Systematic patrols to detect sea turtle nesting on North Padre Island began in 1986, with increasing patrol efforts each subsequent year. Each summer, NPS staff members, USGS staff members, and volunteers search 125 km of Gulf of Mexico beach front on North Padre Island (including the 105 km length of PAIS) via all-terrain-vehicles. When located, nesting turtles are examined for existing tags and any unmarked turtles are tagged. However, in many instances this is not possible because the turtles re-enter the water before staff arrive. Eggs from virtually all Kemp's ridley and other sea turtle nests detected on the Texas coast are transferred to the Padre Island National Seashore incubation facility for protected care; emerging hatchlings are released at PAIS (Shaver 1990, 1997).

During the last 50 years (1948-1998), more confirmed Kemp's ridley nests were located at PAIS than at anywhere else in the U.S. (Shaver and Caillouet 1998). During this time, 45 Kemp's ridley nests were documented on the Texas coast. All 45 confirmed nests were found in south Texas, with 28 documented at PAIS. Thirty-two of the 45 nests occurred between 1995-1998, with numbers increasing during each of those four consecutive years. The recent increase in detected nesting may reflect increased nesting, improved patrol and nest location efforts, increased awareness and reporting by the public, or a combination of all of these factors.

Six of the 32 confirmed Kemp's ridley nests found on the Texas coast from 1995-1998 were conclusively linked to five turtles from the experimental imprinting project (Shaver 1996a, 1996b, 1997; Shaver and Caillouet 1998). The Kemp's ridleys currently nesting in south Texas are probably a mixture of both returnees and turtles from the wild stock, with some individuals nesting both in Mexico and south Texas. The Kemp's ridley population is increasing (USFWS and NMFS 1992; TEWG 1998) and as the population continues to increase and more turtles from the experimental project mature, nesting in south Texas will likely increase. Given the potential for recovery of this species, it is important to ensure their protection at the nesting beaches and in the marine environment.

SEA TURTLE STRANDING AND SALVAGE NETWORK

Sea turtles that strand (wash ashore, alive or dead) in the United States are documented by the Sea Turtle Stranding and Salvage Network (STSSN), which was established in 1980. Live turtles are taken to rehabilitation facilities and dead turtles are often salvaged for necropsy and study. At PAIS, turtles found stranded in Texas are tallied and their attributes are studied.

Although adult Kemp's ridleys forage in, and migrate through, near shore waters of several coastal states, more adult Kemp's ridleys have been documented stranded in Texas than in any other state of the United States (Shaver *in press*). From 1995-1998, when increased Kemp's ridley nesting was detected on the Texas coast, 76 adult Kemp's ridleys were documented stranded on Gulf of Mexico beaches in south Texas; all 76 were found dead and about half of these occurred at PAIS. Seventy-five of the 76 were found at times when Gulf waters were open to shrimp trawling. Much of this mortality occurred during the Kemp's ridley mating and nesting seasons and the deaths of adult Kemp's ridleys in south Texas waters during this critical time in their life cycle could adversely impact efforts to establish a secondary nesting colony there (Shaver *in press*).

SATELLITE TRACKING

Since 1997, satellite transmitters have been attached to a few Kemp's ridleys that nested in south Texas, to identify nesting sites, study movement patterns, and delineate areas of vulnerability to various threats in the marine environment. Two transmitters were deployed during 1997 and four during 1998. After completion of egg laying for the year, all six turtles traveled northward and spent the majority of their time in Gulf of Mexico waters off Louisiana and the west coast of Florida. These investigations documenting movement patterns and habitat preferences of Kemp's ridley sea turtles can provide a scientific basis for future management and policy decisions concerning the protection and restoration of this species.

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PROTECTING SEA TURTLES DURING DREDGING BY THE U.S. ARMY CORPS OF ENGINEERS

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Sea turtles are distributed in the Gulf of Mexico from Texas to Florida and in the Atlantic Ocean from Florida to Nova Scotia (Hildebrand 1982; Hopkins and Richardson 1984; Lee and Palmer 1981; Nelson 1988; Rebel 1974). On the east coast of the United States, loggerhead turtles are found in inshore waters of Rhode Island (Keinath 1986), New York (Burke 1990; Burke and Standora 1991; Morreale *et al.* 1992), Virginia (Byles 1988; Keinath 1993; Lutcavage and Musick 1985; Musick 1979), North Carolina (Epperly *et al.* 1995; Keinath *et al.* 1992; Keinath 1993; Shoop and Kenney 1992), South Carolina (Van Dolah and Maier 1993), Georgia (Stoneburner 1982), and Florida (Bolton *et al.* 1994; Butler *et al.* 1987; Mendonca and Ehrhart 1982).

Except when the adult females come ashore to nest, sea turtles generally occur singularly and move over large areas in coastal marine waters. This solitary, wide-ranging behavior insures that studies of these animals are difficult, time consuming, and expensive. However, studies on sea turtle behavior in aquatic habitats are important not only to increase our knowledge of this part of their life cycle but to assess the causes and to prevent impacts of human activities on these species (National Research Council 1990; Thompson *et al.* 1990). This is particularly true in near-shore and entrance channel aquatic habitats where the primary causes of sea turtle injury and mortality are channel dredging, shrimping, recreational fishing, and boat traffic (National Research Council 1990; Renaud *et al.* 1995; Slay and Richardson 1988). To reduce impacts from these human activities, and to help management make informed Resource decisions, behavior information has been critically needed. Resource managers need specific behavior data such as surface durations, submergence durations (breath holding), and bottom durations to calculate population estimates accurately. Such data are also required to limit bottom trawling time by commercial fishermen and to design methods to prevent entrainment by channel dredgers. However, aquatic behavior research on sea turtles has been limited to a few animals in a limited number of geographic locations.

The U.S. Army Corps of Engineers initiated studies to fill the void in our knowledge of sea turtle activities in near-shore and navigation channel environs and to determine methods to minimize sea turtle entrainment by hopper dredges. On the east coast of the United States, studies were conducted in Charleston Harbor entrance channel, South Carolina (Keinath *et al.* 1995); Savannah entrance channel, Georgia (Keinath *et al.* 1995); St. Marys entrance channel, Georgia (Nelson 1996); and Canaveral entrance channel, Florida (Standora *et al.* 1993). On the Gulf Coast, studies were conducted in Tampa Bay entrance channel (Nelson in preparation). The focus of the research was to identify and compare seasonal sea turtle vertical movements within the water column, in addition to comparing horizontal movements relative to the entrance channel seasonally. Relative abundance surveys were conducted with trawlers to determine the times of least sea turtle abundance. Behavior studies were conducted using radio and sonic telemetry to determine diving activities and local movement patterns. In addition, satellite telemetry was used to determine large-scale seasonal movement patterns.

As a result of these studies, several measures to prevent the entrainment of sea turtles during dredging have been made available to dredging managers. These include restricting dredging to the seasons with colder water when turtles are least abundant, sequencing of dredging from channels with the most turtles to channels with the least, installation of deflector dragheads and relocation of turtles out of the channel during dredging. Since none of these measures is 100 % effective for all situations, each measure individually and in combination is being implemented by the US Army Corps of Engineers to manage their dredging. Restricting dredging to the winter season when water temperatures are coldest and less suitable for sea turtles has proven to be very effective. However, this restriction is no longer effective when dredging must be scheduled outside this window or when water temperatures become unseasonably warm within the window (as in 1999) (Nelson 1999). Sequencing dredging to dredge channels with higher densities of turtles during the colder months is also very effective; however, not all channels can be dredged during the three- or four-month winter season. The deflector draghead works well in soft sediments. However, when the sea floor is uneven the draghead can not maintain contact with the bottom. In such situations, turtles are exposed to the intake on the draghead. The effectiveness of relocation trawling has been debated because it is difficult to evaluate. Sea turtles have been taken by the dredge even though relocation trawling was underway. Turtles can not be completely excluded from the channel by the trawling since they are constantly moving in and out of the channel and may return to the channel area after relocation. Even though not all turtles are captured and removed from the channel by the relocation trawling, no relocated turtle has ever been observed as part of the dredge take. If a relocated turtle were entrained, it would be identified by a flipper tag and/or an internal pit tag installed on all relocated turtles.

Results from these studies have allowed the US Army Corps of Engineers to reduce the entrainment of sea turtles by an estimated 95-99 %.

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THE NAVY AND MARINE MAMMAL CONCERNS THAT CAN APPLY TO THE GULF OF MEXICO

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INTRODUCTION

The U.S. Navy is deeply committed to operating in an environmentally safe manner (see Navy website at *http://206.5.146.l00/n45/branch/n454/.*). In order to foster better understanding of the potential effects from sound and to develop the means to better assess and mitigate such effects, the Office of Naval Research (ONR) has initiated research. We hope that the information thus obtained will not only facilitate the U.S. Navy's requirements to meet its commitment to environmentally safe operation, but will also be useful to other federal, state and local agencies, to relevant industry and other non-government parties, and to the overall public interest. While the Navy has relatively few activities in the Gulf of Mexico (GOM), it recognizes that research involving commonly used sound sources may have applicability to issues in the GOM faced by the Minerals Management Service and other public and private organizations.

The ONR program is one of scientific data-gathering and dissemination. While it is typically considered desirable that legal guidelines and policy rely heavily on science-based information, it is important to keep in mind that the two processes are independent; therefore, one should not draw premature conclusions from this presentation about implications for Navy or national policy, guidelines or regulations. In some cases I will describe experimental designs that have not yet produced data. In other cases I describe work so recently completed that there has not been time for full peer review and incorporation into an accepted body of knowledge upon which to base legal and policy decisions. In all the projects I discuss, the concept, execution, interpretation, and dissemination of the work is considered to be the property of the researcher. For example, the determination of temporary threshold shift effects (TTS) from impulse sound is a scientifically feasible project, and one that is currently being undertaken by investigators under ONR sponsorship. However, the ultimate use of such information in policy or guidelines is still unclear, and hinges on discussions as far-reaching as the relationship between permanent and temporary hearing loss, the legal definition of "harassment" under the Marine Mammal Protection Act, and the ability of organisms to cope with decreased auditory function in both the short and long term. It would be beyond the scope of this discussion (and the author's expertise) to speculate on the significance of such information for Navy or national policy and procedures.

SOME BACKGROUND ON THE OFFICE OF NAVAL RESEARCH AND ITS ROLE

The Office of Naval Research was created in 1946 to continue the successful interaction between universities, government and industry that emerged during World War II. ONR was the first formal, large scale government program to foster basic research outside the government and was a model for other federal research funding agencies, such as the National Science Foundation (Vest 1996). The role of the current ONR remains much the same, over 50 years later. Success for ONR programs, is as much about metrics of academic achievement such as peer-reviewed publications and Nobel prizes as it is about delivering new technology to the Navy. As you will see, the ONR research program into the effects of underwater sound on marine organisms takes advantage of ONR scientific leadership in such areas as underwater acoustics and marine mammal biology to provide cutting edge science that is not only useful to the Navy, but contributes to a generally accessible knowledge base with a wide range of potential uses. The work involves expertise and facilities at universities, Navy research laboratories, National Marine Fisheries Service, and the Army. All work from the program is unclassified and is usually published in scientific journals or other publically accessible sources under academic peer review.

RATIONALE FOR THE ONR PROGRAM

Lethal and injurious effects from shock waves and sound overpressure or energy flux are well documented and need not be discussed in detail here (see Yelverton 1981; Young 1991; Ketten 1995). Larger animals are likely to withstand greater peak pressures than smaller animals. Keep in mind that these are received values; source levels might be much higher, depending on the range from the source. Also, these are very sudden sharp pressure changes associated with impulse events; equivalent peak pressures in tonal sounds would be less likely to induce damage due to the slower acceleration of tissues by the slower, smoother pressure changes in tonal sounds, with the possible exception of resonant frequencies that can result in damage from recurring oscillations of the resonating space, e.g. resonance of the lungs leading to tissue damage.

Determination of physiological effects from non-impulse sound is less well studied. ONR is currently co-sponsoring research with human divers and terrestrial animal models (mice, rats, guinea pigs and pigs) to determine behavioral and injurious thresholds for low frequency tonal sounds between 100 and 2500 Hz. What few results we have in this new program are not ready for reporting at this meeting but will become available over the course of the year through peer-reviewed scientific publications by the researchers and other public-release reports. As might be expected, it is unlikely that we will see a proposal containing a legally and ethically acceptable technique to test live marine mammals with potentially damaging levels of noise. We will therefore probably be forced to extrapolate from terrestrial animal models, with the attendant uncertainties that arise from physiological differences between terrestrial mammals and marine mammals. At present, the lowest clear and reproducible damaging effect in terrestrial animals (rats and mice) comes from resonance of gas-filled spaces such as the lung, with onset of injurious effects after a few minutes exposure at around 180 dB re 1 microPascal (received SPL) at the resonant frequency, and at 190+ dB at nonresonant frequencies just a few Hz to either side of the resonant frequency. Since the lung resonant frequency of humans and therefore almost all marine mammals is lower than 45 Hz (slightly higher at depth), most impulse sources and all existing and planned LF sonar sources will be too high frequency to excite lung resonance. We are still looking at possible harmonic resonance frequencies, resonance frequencies of sub-spaces such as single alveoli or bronchioles, and resonance of other smaller gas-filled spaces such as in the gastro-intestinal tract that might fall within the frequency range between 100 and 3,000 Hz. Other suspected effects, such as vestibular effects (vertigo, nystagmus, etc.), disruptions of cardiac rhythms, or effects on central or peripheral nervous tissues have not been found, but work is still ongoing.

At the other end of the spectrum are noninjurious behavioral responses. Hypothetically, any sound that can be heard could elicit a behavioral reaction. In reality, the probability of eliciting a reaction, and the type of reaction elicited, can vary greatly with species, individual experience, alertness or the nature of the sound and the circumstances under which it occurs. Because of the tremendous variability of behavioral response, it will undoubtedly be very difficult to develop metrics for “harassing” sound or some other boundary between biologically significant or consequential noninjurious sound levels and inconsequential but audible sound levels. ONR and other Navy activities expect to generate data on behavioral reactions in the course of monitoring and mitigation efforts, but it will probably be some time before sufficient data accumulate to suggest any general predictive relationships between impulse events and behavioral reactions.

In this context ONR has focused on quantifiable physiological or percept-based effects of impulse sound that can be experimentally induced, replicated and verified in statistically meaningful ways, but that bridge the region between injurious effects and more variable, less predictable behavioral responses.

TEMPORARY THRESHOLD SHIFT (ITS)

This study is being carried out under the leadership of Dr. Sam Ridgway at the Space and Naval Warfare Systems Center (SSC) in San Diego, using a sound source provided by the Naval Surface Warfare Center (NSWC) in Carderock, Maryland. The TTS protocol developed by Ridgway and his colleagues at SSC has been used to generate data on the levels of pure tones that induce a small (six decibel), quickly recovered hearing loss (Ridgway *et al.* 1997). Using the impulse sound simulator developed by NSWC, Dr. Ridgway employed the same protocol to determine the onset of brief temporary threshold shift to a simulated signal replicating an impulse event at some range from the source. The NSWC device uses multiple tonal transducers to produce a plane wave that replicates an impulse sound through the constructive and destructive interference of the different individual signals produced at each transducer. The simulator cannot replicate the sharp microsecond duration waveform found at or near a source, but it can replicate the more spread out signal found at ranges of thousands of meters from the source. At that range the signal is still only a few tenths of a second long, at most, and therefore still much shorter than the tonal signals, which usually last a second or longer. Sound pressure levels at the limit of the device’s capability (220 dB peak-to-peak, or 170 dB RMS) failed to induce TTS, so we are seeking impulse sound sources capable of producing higher energies. We are currently seeking other impulse sources such as airguns and sparkers, and would appreciate any assistance MMS and industry could give us in obtaining an impulse sound source that could be used in a safe stairstep methodology for assessing ITS. Other planned work with tonal and impulse sounds includes establishing the scaling relationship between repetitive sound or duty cycle and recovery from ITS, effects of signal duration on ITS, and contribution of masking or background noise to the observed TTS effect.

The onset of temporary threshold shift to short (one second) tonal signals at frequencies between 400 Hz and 70 kHz has been on the order of 190-200 dB. We anticipate that responses to shorter duration impulse events will be at similar signal strengths, but that is a question best resolved by the empirical data. However, we still do not know if there will be greater variability in the onset levels from test to test than we are seeing for tonal signals or if the broadband impulse events will exhibit stronger effects on certain hearing frequencies due to the mechanical properties of the ear or for other reasons. In terrestrial mammals, ITS to impulse sounds tends to be more variable than to tonal sounds, probably due to irregular reactions by ear protective mechanisms and effects of orientation. Terrestrial mammals also tend to show greater ITS effects at higher frequencies than the stimulus, probably due to the shape of the inner ear.

Ridgway employs an operantly conditioned, food-reinforced testing procedure that tends to produce the greatest and most consistent indication of hearing sensitivity The effects of methodology on results are being assessed by independent parallel efforts undertaken by Ron Schusterman of the University of California at Santa Cruz and Paul Nachtigall and Whitlow Au at the University of Hawaii. Three species of marine mammal are being tested at SSC; California sea lions (*Zalophus californianus)*, bottlenose dolphins (*Tursiops truncatus)*, and beluga or white whales (*Delphinapteras leucas)*. The experiment begins with a pre-test hearing check, then after a variable delay, the “inducing” sound stimulus is played and another hearing check is administered. When hearing is checked after the inducing sound and a decrement of six decibels is obtained (the minimum statistically significant difference in this particular design), a temporary threshold shift is said to have occurred, and the level and duration of the inducing signal is noted. For the short duration signals used thus far (most are one second long), recovery to pre-test levels generally occurs within 15-30 minutes of the ITS event. Animals must return to full pre-test levels before they are allowed to do another ITS test. Up-to-date results from these three parallel independent studies will be presented at the Acoustical Society of America meeting in Columbus Ohio in October 1999. ONR anticipates a lot of interest not only in the presentations, but in the discussion among presenters and audience members due to the potential significance of these data to our understanding of how marine mammal ears respond to underwater noise and the potential regulatory implications of such data.

ITS is of interest for two reasons. First, it bears some relationship to Permanent Threshold Shift (PIS). Though the causal relationship is not clear, it appears that repeated ITS events can lead to PTS, and onset of ITS bears a fairly consistent relationship to onset of PIS (generally, PIS occurs about ten decibels above ITS, though this can vary) (Kryter 1985; Ward 1991). Since it is undesirable to deliberately induce PIS to determine the actual onset of permanent hearing damage, testing for ITS at least gives us a “ballpark” number from which to estimate a general sound level at which PIS may be likely. Second, ITS means that an individual is temporarily deprived of a specific degree of hearing acuity and for a specific duration. During that time the individual has a reduced ability to receive environmental sensing and communicative acoustic information. The quantification of ITS effects thus permits more reliable and precise risk assessments about the effects of a given sound source with the potential to cause ITS.

MEASUREMENT OF MACRO AND MICRO SCALE DAMAGE FROM IMPULSE EVENTS

Since it would be impossible to test for damage effects in live, free-ranging animals, this experiment makes use of specimen materials collected by the National Marine Fisheries Service Stranding Program. According to Dr. Darlene Ketten of Woods Hole Oceanographic Institution and the Harvard Medical School, even microscopic structures such as the cilia on inner ear hair cells retain their structural mechanical properties for a considerable period post mortem. Thus, they may be used to construct predictive mechanical models of the damage likely to be induced in live animals by a given impulse event, even if the effects are restricted to such microscopic effects as damage to hair cells, with no other obvious injury.

Dr. Ketten will use special techniques that she developed for high resolution x-ray computed tomopgraphic scanning (CT scan) to create 3-D images of intact ears in specimens provided by the NMFS Stranding Program (see Ketten 1997). The specimens will be CT scanned before and after exposure to a controlled, measured impulse event, and then standard histological techniques will be used to further assess the nature and extent of damage induced by a given impulse event provides a schematic illustration of the sequence of experimental procedures. Sound output from explosives scales with charge size (Kibblewhite & Denham 1970), 50 small charges contained in test pools are sufficient to establish predictive relationships for larger at-sea impulse events without the risk of uncontrolled inadvertent exposures of marine life during testing. Likewise, effects scale with the size and robustness of the ear structures (Ketten 1995), 50 tests will be conducted on small specimens (harbor porpoises) and tissue blocks containing the ear structures and surrounding supportive tissues for larger species like baleen whales.

In addition to impulse waveforms from explosives, other impulse waveforms, such as those from airguns, may be tested. Eventually the energetic correlates of damage can be merged with measured dimension, mass and resilience of auditory structures to create a predictive model of damage, such as exists for human in-air auditory damage from guns and explosions (Price & KaIb 1996). The Price model is currently used to establish exposure safety standards for the U.S. Army and NATO for in-air impulsive noise. It should be relatively easy to adapt this model for marine mammal and human ears underwater to provide a similarly useful predictive model of damage from underwater impulse events.

CONTROLLED EXPOSURE STUDIES

Beginning with the ATOC Marine Mammal Research Program in 1994 the scientific community has shown a growing ability to perform complex integrated biological studies at sea to monitor the effects of a sound source on large (hundreds of square miles) zones of potential effect. Initially, monitoring of sound sources was largely limited to aerial and shipboard visual surveys for surfaced animals, but increasingly complex data sets are being gathered by the integration of multiple passive acoustic monitoring tools (sonabuoys, bottom-mounted arrays, towed arrays, vertical arrays) and attachable dataloggers for recording the movements of the animals and the ambient conditions through which they pass. Most recently, these data have been merged with complex 3-D sound field modeling, physical and chemical oceanographic data from ships, satellites and buoys, and prey field mapping with high-frequency acoustics and net tows. When these data are assembled, they provide very sensitive and powerful statistical estimates of behavioral response to sound that are not confounded by animal response to food, conspecifics or physical changes to the environment, as was the case in earlier pioneer work with ATOC and some industrial noise sources. The data also provide unprecedented insights into the animal's three-dimensional underwater world and its interaction with that environment through underwater movements, vocalizations and other behavior previously unaccessible to the surface-based marine mammal scientist. The LFA sonar Scientific Research Program, co-sponsored by ONR and other branches of the Navy reflects the current state-of-the-art in multi-methods monitoring with a controllable sound source. Reporting of data from that program is expected to continue throughout the coming year, including release of the LFA EIS some time later this summer (exact date is not yet known).

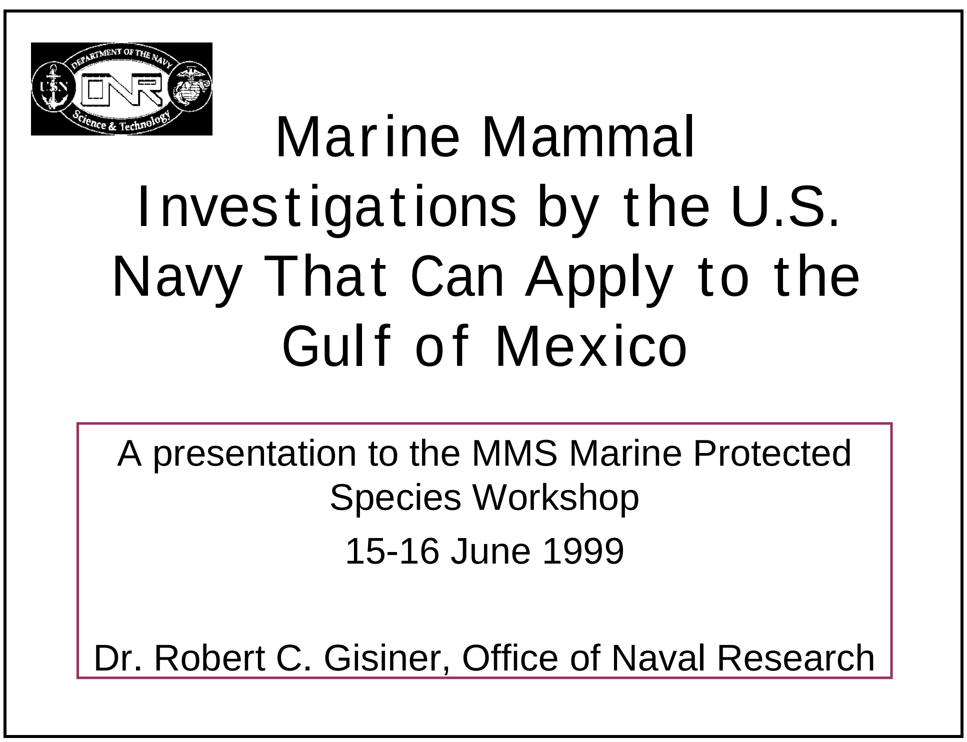
ONR plans to continue similar controlled noise exposure studies with sound sources and marine mammal species or localities of greatest interest to the community at large. At present, Mediterranean deep divers (sperm whales and Cuvier's beaked whales) and north Atlantic right whales are among the species and localities of greatest interest. ONR is working with Navy and non-Navy potential partners to put together multi-disciplinary studies of the biology and response to noise of these species. As further data come in from the ITS, human diver safety, and other programs, we expect to have even more confidence in our ability to introduce safe levels of sound and ramp up in a carefully controlled manner to thresholds of behavioral aversion without risk of injurious or serious and widespread behavioral effects. Key to such a process will be the inclusion of international, national, state and local entities as well as concerned citizens' organizations and professional peers in a process of oversight both in the planning of the controlled exposure study and in the review of work in progress and final reports.

CONCLUSION

The types of experiments described above should provide a detailed and statistically strong set of metrics for risk assessment and damage prediction, even for very small damaging effects. These data can serve as cross-checks to each other and to current predictions based on human or terrestrial animal models, since the phenomena they measure overlap. Both Ketten's and Ridgway's data should support predictive math models that can be used to extend their results to impulse and tonal sources of different types, and the models should scale in predictable ways for animals of different size.

These experiments, which should be completed within the next two years, should enable us to establish very definite criteria concerning the potential for injury and temporary performance losses from impulse sound, ranging from lethal and serious effects, to tiny recoverable effects. As indicated earlier in this paper, the potential for purely behavioral effects is much more difficult to assess, and will probably produce much more variable outcomes that will be difficult to reconcile to simple models for impact assessment and prediction. At some point, NMFS and the interested community at large will probably want to make a cost-benefit analysis of the remaining risk after immediate damaging effects have been clearly defined and mitigated. While it is possible that some risk may exist from adverse behavioral or cumulative sub-threshold effects, it remains to be seen whether such effects constitute a significant threat to individual or population survival and well-being, and if so what kinds of efforts and what level of support will be required to resolve these remaining questions.

The slide show that accompanied this presentation follows.



The Issue

- Manmade underwater sound is increasing
  - due to increased shipping and industrial activity
  - due to increased importance for military activities
  - due to increased use for research and exploration
- There is potential for harmful effect
  - lethal or injurious effects of high energy sources
  - disruptive effects on sensing and behavior
- The law requires us to assess and minimize impact
  - Marine Mammal Protection Act, Endangered Species Act
  - for government in particular: NEPA, EO 12114

The Navy Response

- A large ONR research program,
- linked with efforts by CNO N45 and technology acquisition program offices,
- coordinated by the Office of the Secretary of the Navy, plus
- monitoring and mitigation programs for Navy acquisition programs (e.g. ship shock testing and LF sonar tests) will also be used as data sources
- data dissemination to NATO, other federal agencies, public.

What information do you need to assess risk?

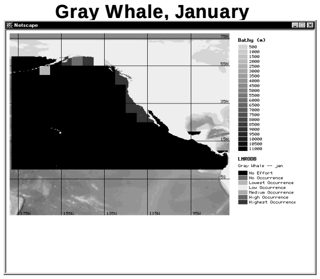
- Characteristics of *all* sound sources:
  - including pingers, modems, calibration signals, etc.
  - fully characterized: duration, duty cycle, source level, waveform or time/freq display, directionality, etc.
- Area ensonified
  - sometimes simple models of spherical or cylindrical spreading will do, but most often a PE or other complex model is best.
- Who's there?
- What is their likely response to the sound?

Who's There?

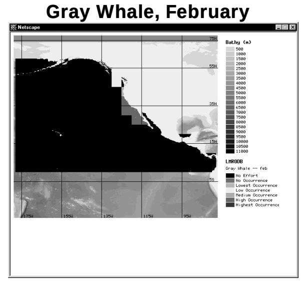
- The Navy, in collaboration with NOAA, is developing abundance and distribution databases
  - they enable quick preliminary assessments of risk
  - they are probably the easiest and biggest impact mitigation tool you can get.
- A preliminary version, Living Marine Resources Information System, developed as a tool for Navy planners and ship operators, is going into fleet use within the next 1-2 years
  - Added tool, such as the Acoustic Integration Models are in development

LMR Occurrence Displays

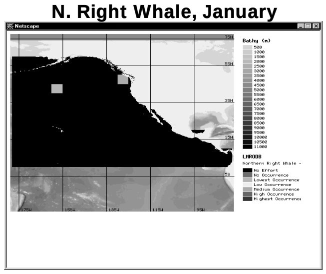
Gray Whale, January



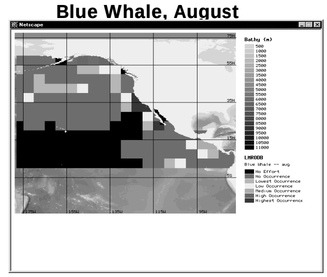
Gray Whale, February



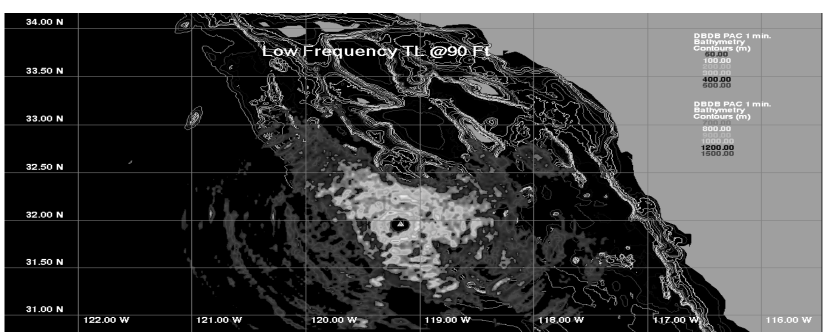
N. Right Whale, January



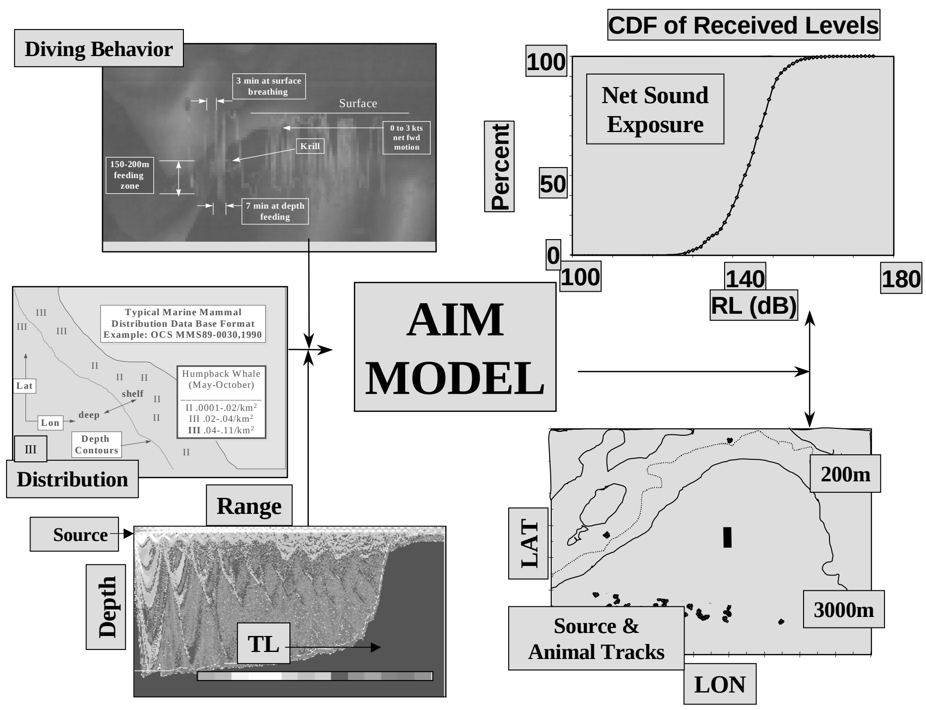
Blue Whale, August



TL Prediction, Navy PE Model



A TL "slice" showing signal intensity at 90 feet in depth is plotted given a mid-water column located source in an "acoustically shallow" region.



What's the likely response?

- Lethal and injurious effects:
  - human diver and laboratory animal studies suggest onset in the 180-200 dB range for LF tonal sounds
  - impulse effects studies with dead specimens from stranding networks
  - is Temporary Threshold shift the "highest safe" measurement for auditory specialists?
- Behavioral Effects
  - direct observations in lab and field settings
  - hearing data: "if it is audible it is potentially able to affect behavior."
- Chronic sub-threshold effects
  - effects of repeated or prolonged exposure that produces no obvious reaction

Rochester: DRT for Lung Hemorrhage

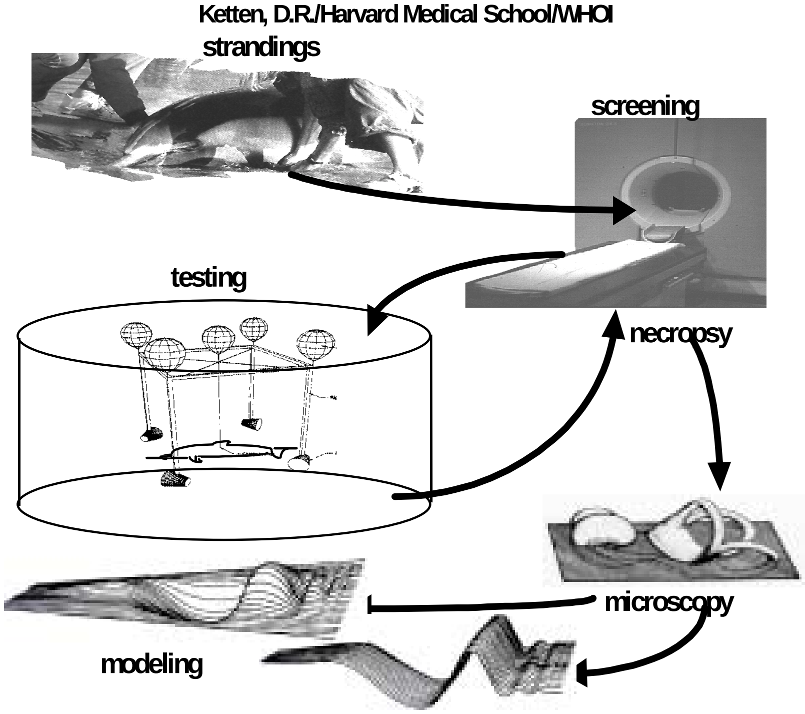
- *DRT for mice at RF (mean 328 Hz), 300 and 350 Hz:*

dB SPL	*Freq*	*Damage*
184.1	*RF*	*lung hemorrhage*
184.6	*RF*	*liver hemorrhage*
189	*RF*	*air in chest*
190.5	*RF*	*air in abdomen*
186.5	*300 Hz*	*lung hemorrhage*
188.8	*300 Hz*	*liver hemorrhage*
188.0	*350 Hz*	*lung hemorrhage*
188.8	*350 Hz*	*liver hemorrhage*

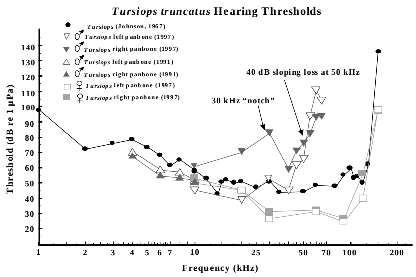
- *No significant damage occurred at maximal SPL of the G40 for animals exposed to 100, 250, 400 and 500 Hz.*

Marine Mammal Blast and Acoustic Trauma Measures

Ketten, D.R./Harvard Medical School/WHOI



Dr. Darlene Ketten
Woods Hole, O.I.; Harvard Medical School
“Predicting Hearing from Anatomy”



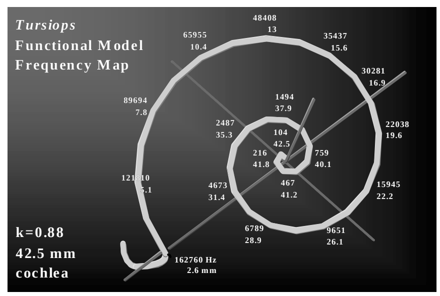
•Has provided the ONLY data on hearing performance of baleen, beaked whales.

•Currently developing predictive model of effects from inpulse noise (explosives, air guns, etc.)

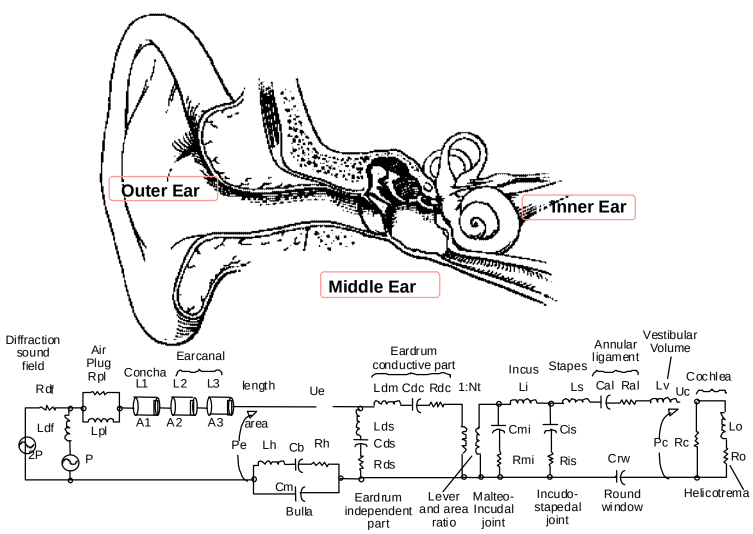
•Employs hi-res CT scanning & std. Histology to get 3-D anatomy of ear

•Applies biomechanical models & neurophysiology to predict performance.

•Verifies predicted performance with behavioral calibration.

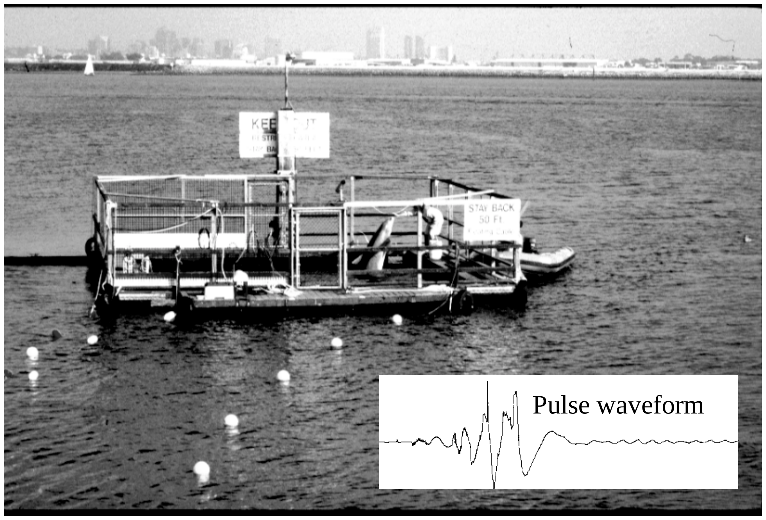


Develop Predictive Models of Auditory Response (Ketten, Price)



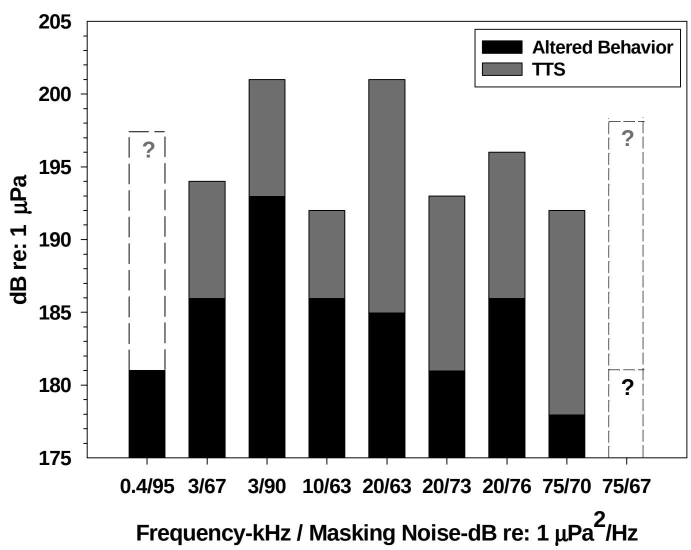
MARINE MAMMAL ACOUSTIC SAFETY CRITERIA

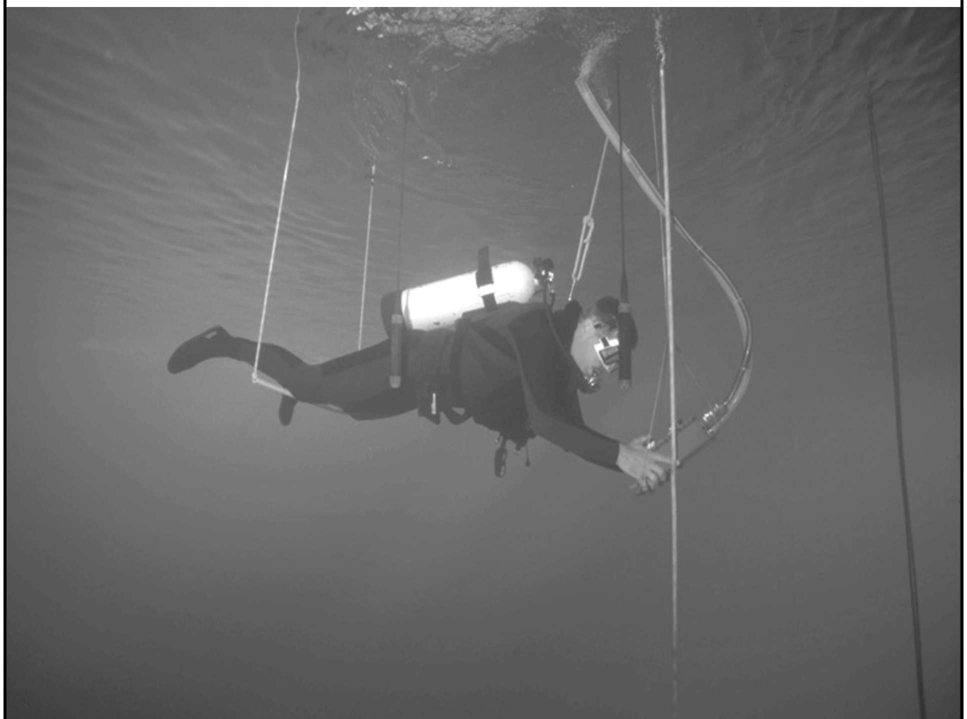
EXPLOSION SIMULATOR TEST ENCLOSURE



MARINE MAMMAL ACOUSTIC SAFETY CRITERIA

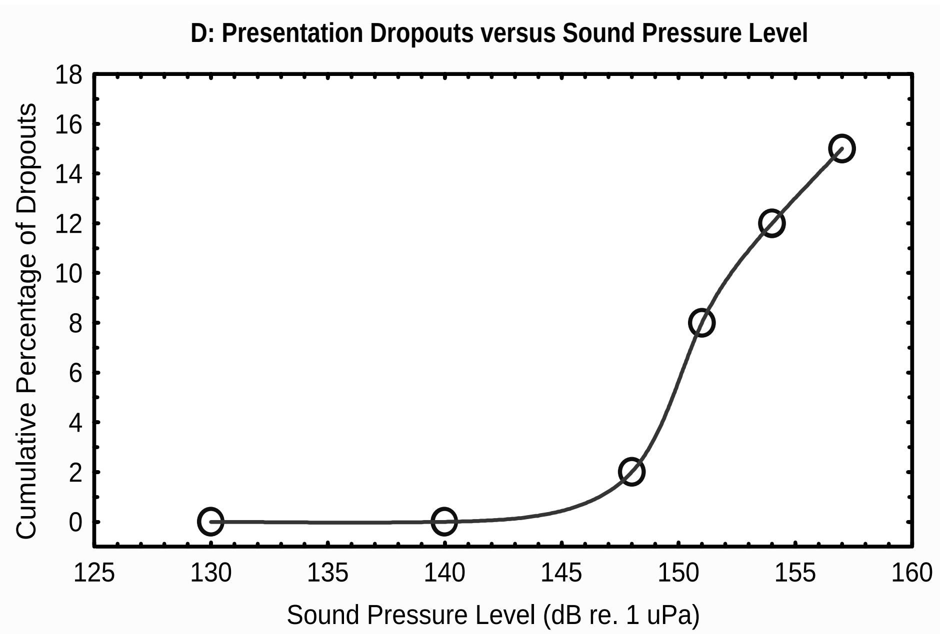
FY98 ERAT End of Year Review
Results to Date





NSMRL: Psychological Results

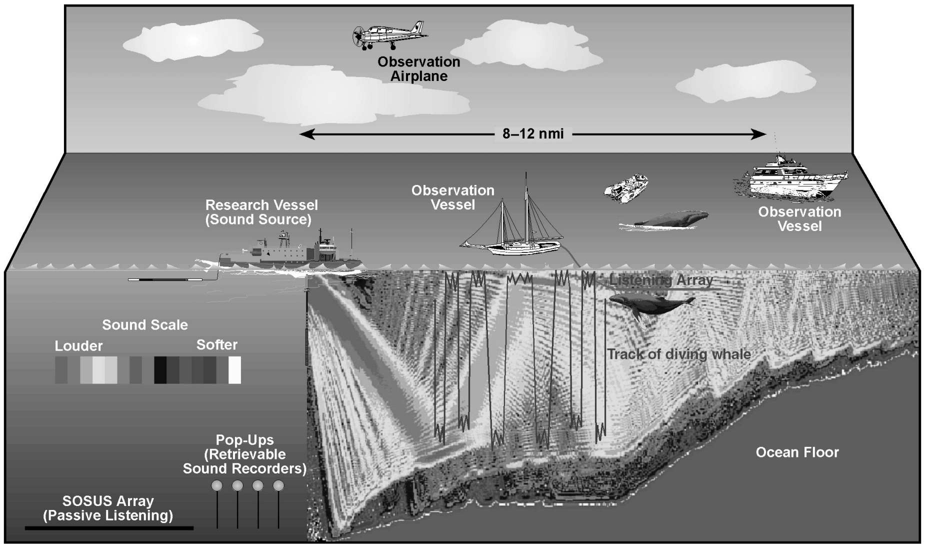
- *No divers aborted any of the dives*
- *Auditory thresholds from 100 - 500 Hz decrease linearly with frequency from 99 to 85 dB re 1μPa*
- *The aversion function is U-shaped with a minimum at 250 Hz*
- *Increasing duration from 7 to 28 seconds did not increase aversion*
- *Divers started reporting aversion rating at or above severe at 148 dB*



MCES - multi-method controlled exposure studies

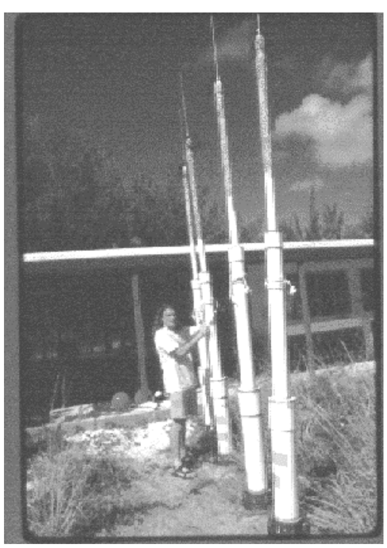
- Put the animals in their environment
  - physical, chemical, biological, social, other human activities.
- Strive to recreate the 3-D movements of the animals
  - surface observations, plus underwater acoustic monitoring, tagging, and other tools
- Use a controllable source
  - start very safe and step up, monitoring as you go.

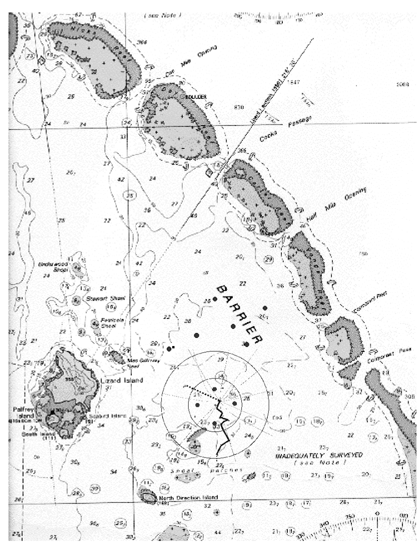
The SURTASS LFA Scientific Research Program

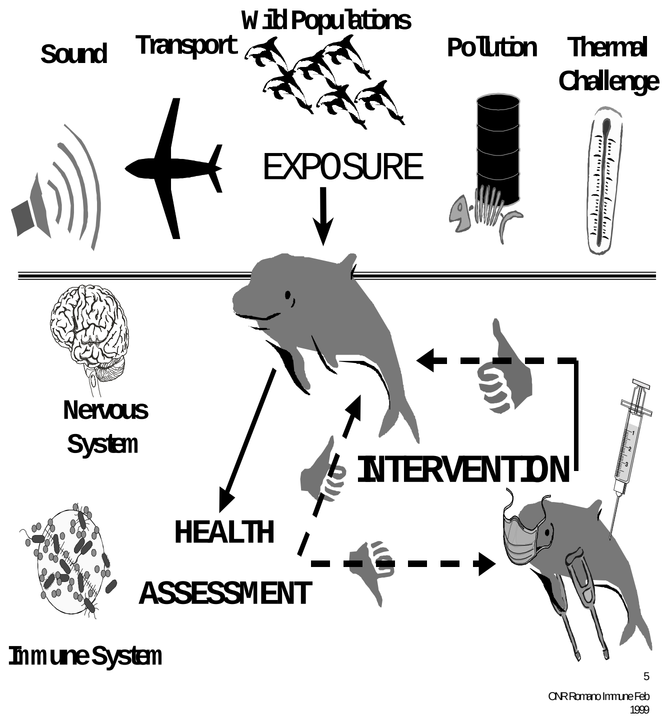


Passive Acoustic Monitoring Tools

(Gedamke, UCSC. Minke whales on the Great Barrier Reef)







Monitoring & Mitigation

- What you don't know CAN hurt you
  - monitor to verify predicted sound field, distribution and abundance of species of concern.
  - monitor to accrue data that reduces current precautionary standards based on uncertainty
  - monitor to effectively deploy mitigation
- Monitoring is more than whalewatching!
  - Doing more than recording surface detections usually pays off
  - use passive acoustics used for other tasks
  - use environmental data to account for variables other than sound which might also affect activity.

Mitigation

- Your two best mitigation tools are:
  - choose sites, times with the least impact
  - a quieter source with better energy focusing or receive/signal processing
- Monitoring is data: prepare the infrastructure to use lessons learned from previous activities in future activities
  - animal distribution data
  - responses of animals to sound source
  - effectiveness of mitigation

Marine Mammal Science Environmental Compliance

Critical S&T Areas

[established by 1995 NRC Panel Report, 1997-98 LF Sonar Science Advisory Board, 1998 Workshop on Effects of Anthropogenic Sound]

- Hearing
  - low frequency hearing thresholds
  - masked hearing thresholds, critical ratios
  - temporary threshold shift effects
  - hearing damage from impulse sound (explosives, sonic boom)
  - hearing from anatomy and remote physiological msmts.
- Behavior
  - behavioral changes correlated with exposure to human noise.
  - Uses of sound by marine mammals, functional significance.
  - Long term effects such as changes in distribution, sensitivity.
- Tools
  - attachable tags, sensors, dataloggers
  - use passive acoustics to monitor vocal animals (e.g. SOSUS)
    - novel sensors; active sonar, infrared, satellite imagery
    - Risk assessment & prediction models.

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Young, G.A. 1991. Concise Methods for Predicting the Effects of Underwater Explosions on Marine Life. Naval Surface Warfare Center, NAVSWC MP 91-220. July, 1991.

Dr. Robert Gisiner is the Marine Mammal Science program officer for the Office of Naval Research. He manages basic and applied research programs in effects of anthropogenic noise on marine mammals, biosonar, biolocomotion, and diving physiology. Dr. Gisiner is also a member of the Steller Sea Lion Recovery Team and the Coastal America Science and Technology Advisory Group. He received his Ph.D. in biology from the University of California at Santa Cruz. His research interests include behavioral ecology, animal cognition, and biosonar.

SUMMARY

RECOMMENDATIONS AND PROPOSED ACTION ITEMS

As explained in the introduction, this meeting incorporated more formal presentations than in past MMS protected species workshops and used a panel of experts (see Appendix B) instead of breakout groups and discussion leaders. The presentations provided updates and background on biological research and industry technology and activities; they also addressed the status of the Marine Mammal Protection Act and Endangered Species Act.

After the presentations, the panelists addressed issues of concern in their areas of expertise, followed by questions, discussion and debate with the audience. Attendees also submitted written comments and information to the MMS. A court reporter provided transcripts for this session, in addition to a post-workshop, closed meeting held with the panel, MMS staff, and other federal representatives on the following day.

From these sources, an outline of findings and recommendations was prepared and a list of all potential action items identified. This list was then evaluated in terms of potential MMS actions and relevance to MMS regulatory responsibilities. What follows is the MMS response to the information and recommendations provided from the workshop.

BASELINE INFORMATION

Although information about GOM cetaceans has increased dramatically in the last 5-10 years, the workshop participants repeatedly stressed the need for additional information on species composition, numbers, seasonal distribution patterns and environmental correlates. In addition to "better numbers," we need better to understand population trends and to detect any abnormal changes attributable to human activities.

Any group working on protected species concerns in the GOM needs these data. For NMFS, the information is an essential part of their stock assessment efforts. For MMS and the Navy, the information may be considered as baseline information for potential effects assessment. This type of research is a prime candidate for cooperative efforts and, if not co-funded, needs to be coordinated at a regional level—not only through MMS OCS Planning Areas but at a Gulf of Mexico—Caribbean Sea scale.

Of particular concern to MMS is the move by industry into deepwater regions of the GOM and the eastern planning area off Florida. Both the panel and the audience agreed strongly on the need to conduct surveys before industry arrives. Both groups also agreed on the need to conduct surveys based on biological distributions and physical features rather than on artificial political boundaries, which cetaceans and sea turtles do not recognize. Expanding survey work into Mexican and Caribbean areas was recommended.

Also of importance to MMS were comments on cetacean versus sea turtle studies. While sea turtles "are recorded" during cetacean surveys, such sightings are but lagniappe: the field efforts are designed for cetaceans and are notably ineffective for detecting sea turtles, in particular, younger (= smaller) life stages.

MMS has renewed an interagency agreement with NMFS to fund marine mammal observers aboard NMFS spring and fall plankton cruises in the GOM and to pay for data analyses. We are exploring options to conduct cruises in Mexican waters.

Meetings are now held with NMFS and the Navy to better coordinate marine mammal field programs in the GOM and Caribbean. At a minimum, new lines of communication and increased awareness of respective MMS, NMFS and Navy marine mammal studies have been established. Potential for additional cooperative ventures is being explored.

MMS has offered to participate in a planning meeting hosted by NMFS to determine what types of research can be conducted to study sea turtles in deepwater habitats.

EFFECTS OF INDUSTRY

The workshop addressed numerous potential impacts of human activities on GOM manatees, sea turtles, and cetaceans. A fundamental issue, closely related to baseline studies, is how to detect and monitor changes attributable to human impacts and what would be needed to do so. Among the ideas discussed were power analyses to design monitoring programs, ensure long-term efforts, and evaluate the use of offshore platforms as part of field programs. Effects of contaminants, commercial and recreational vessel activities, and noise-producing activities were the predominant topics.

In terms of petroleum industry activities and MMS priorities, the shift to deepwater may expose a significantly different cetacean community (relative to shelf species) to various types of impacts. Of these impacts, the effects of noise and the response of cetaceans to deepwater structures are considered the least understood yet the most certain impacts. The industry activity most likely to create noise impacts was identified as seismic exploration and the species of most concern was the sperm whale. The use of explosives to remove offshore structures was another concern as were oil spills; a large oil spill would have potentially catastrophic impacts, although it is a low-probability event. The lack of information on acoustic effects and/or explosive pressure waves coupled with the fact that these events are operational, not accidental, are compelling reasons to elevate research on these topics to the highest priority for effects studies.

The demand for definitive data on impacts of noise pollution on cetaceans has perhaps intensified since the workshop. While military activities have garnered the most public attention and commercial shipping is acknowledged as the major source of anthropogenic noise, it is clear that seismic operations also represent an undefined, potential threat to cetaceans and perhaps to sea turtles as well.

Strong and clear recommendations from the workshop experts were used to justify a modification to the existing agreement with NMFS to conduct cetacean surveys. Additional cruises have been added, dedicated to research on GOM sperm whale populations, acoustic measurements, and the effects of air guns on sperm whales. The new program—Sperm Whale Acoustic Monitoring Program (SWAMP)—began with a pilot study in June 2000.

Numerous meetings have been held with the Navy since the workshop. The Office of Naval Research (ONR) has joined MMS and NMFS as an active research partner. ONR has provided digital recording tags (D-tags) that are placed on sperm whales and record whale movement and received sounds. In FY2001, satellite tags, funded through ONR, will also be used for recording long-term movement of tagged whales.

MMS has included support for biopsy samples (all species) and DNA analysis of sperm whale tissue during all NMFS-MMS cruises. Archived tissue samples may be used for contaminant analyses. DNA analyses will be used for genetic assessment of sex, family groupings, and stock uniqueness for sperm whales. NMFS will conduct DNA analyses on other cetacean species.

The above MMS responses are expected to cost more than $1 million by FY2001 and to continue through FY2003. These were considered the highest priority for research funds, and costs to accomplish research in deep water are substantial.

OTHER ACTIONS

MMS has also attempted to address several other issues raised at the workshop.

There were several comments from the audience on the need to present issues in plain English and to make information available to the public. This need is not unique to protected species issues; workshop comments reinforced a recognized problem. MMS has established a comprehensive homepage on the Internet, and many environmental studies reports can be downloaded. A special effort was made to describe SWAMP in plain English—details of the pilot cruise may be found: *http://www.gomr.mms.gov/homepg/regulate/environ/marmam/sperm_research.html*. This address will be updated as research progresses.

It was suggested that MMS support the Southeast Marine Stranding Network. Since the workshop, the Louisiana Marine Mammal and Sea Turtle Rescue Program has been re-established at the Audubon Aquarium of the Americas. MMS has played an active role at meetings and helped establish federal contacts. Funding support for this program remains an option.

The role of industry in supporting GOM protected species research was sharply debated several times during the workshop. Since the workshop, several industry workshops and special sessions at national meetings have taken place. Industry cooperation for proposed air gun experiments in SWAMP is likely. The seismic industry is exploring funding research on acoustic effects on marine mammals in the form of an international granting program run through an independent research management organization.

MMS has held extensive talks with NMFS on the regulation of seismic operations and explosive removals. An environmental assessment of all GOM geological and geophysical exploration methods regulated by the MMS is underway. New Section 7 consultations (under the ESA) with

NMFS on use of explosives are anticipated. These efforts should lead to an agreement on industry requirements for take permits and provide answers to questions raised at the workshop on MMPA compliance.

Issues related to manatees, discreet stocks of bottlenose dolphins, and post-hatchling movements of sea turtles in the eastern OCS planning area (Florida panhandle) are under consideration, pending management decisions on leasing. Options to conduct detailed cetacean surveys in the DeSoto Canyon area have been discussed with NMFS.

APPENDIX A

MARINE PROTECTED SPECIES WORKSHOP

New Orleans Airport Hilton
June 15-16, 1999
Agenda

<u>TUESDAY, JUNE 15</u>

<u>BACKGROUND</u>

8:30-8:35 **Opening Remarks**
Mr. Hammond Eve
Minerals Management Service

8:35-8:45 **Objectives/Introductions**
Dr. William Lang and Ms. Dagmar Fertl
Minerals Management Service

8:45-9:15 **KEYNOTE: History of Protected Species in the Gulf of Mexico**
Dr. William Evans, Retired
(last w/Texas A&M University)

9:15-9:35 **Relevant Legislation (Marine Mammal Protection Act, Endangered Species Act)**
Dr. Robert Hofman
Marine Mammal Commission

Mr. David Bernhart
National Marine Fisheries Service

9:35-9:50 **Break**

<u>BIOLOGY</u>

9:50-10:20 **GulfCet I, II – Cetaceans, Turtles, and Habitat Consideration**
Dr. Keith Mullin
National Marine Fisheries Service

10:20-10:40 **Manatees in the Gulf of Mexico**
Dr. Robert Bonde
U.S. Geological Survey

10:40-11:00 **Review of Sea Turtle Information for the Gulf of Mexico**
Dr. Maurice Renaud
National Marine Fisheries Service

11:00-12:30 **Lunch**

INDUSTRY; MAN-MADE AND NATURAL ACTIVITY IMPACTS ON MARINE MAMMALS AND SEA TURTLES

12:30-12:50 **MMS and Deepwater Activities**
Mr. B.J. Kruse
Minerals Management Service

12:50-1:20 **Offshore Platform Operations**
Ms. Sandi Fury
Chevron

1:20-1:50 **Acoustic Activities of Industry**
Dr. Jack Caldwell
Schlumberger Geco-Prakla

1:50-2:40 **Explosive Structure Removals/Navy Explosives Testing**
Mr. Gregg Gitschlag
National Marine Fisheries Service

Mr. William Sloger
Department of the Navy

2:40-2:55 **Break**

2:55-3:40 **Human Activities and Natural Events: Impacts on Gulf of Mexico Marine Mammals**
Dr. Bernd Würsig
Texas A&M University

Dr. Jeffrey Norris
Texas A&M University

3:40-4:25 **Human Activities and Natural Events: Impacts on Gulf of Mexico Sea Turtles**
Dr. David Owens
Texas A&M University

4:30-6:00 **Social**
Ballroom C

WEDNESDAY, JUNE 16

REVIEW OF RELATED RESEARCH AND MONITORING PROGRAMS

9:00-9:15 **Role of a Non-Governmental Organization**
Ms. Sharon Young
Humane Society of the United States

9:15-10:00 **National Oceanic and Atmospheric Administration Gulf of Mexico Marine Mammal and Sea Turtle Programs**

A. Contaminants and Stranding
Dr. Teri Rowles
National Marine Fisheries Service

B. National Ocean Service and Sea Turtles
Mr. Michael Coyne
National Ocean Service

C. Sea Turtles and the National Marine Fisheries Service
Ms. Sheryan Epperly
National Marine Fisheries Service

10:00-10:15 **U.S. Geological Survey/National Park Service Sea Turtle Research and Monitoring Programs in Texas**
Ms. Donna Shaver
Biological Resources Division

10:15-10:30 **Corps of Engineers Protected Species Concerns in the Gulf of Mexico**
Dr. David Nelson
Corps of Engineers

10:30-10:45 **The Navy and Marine Mammal Concerns That Can Apply to the Gulf of Mexico**
Dr. Robert Gisiner
Office of Naval Research

10:45-12:30 **Lunch**

<u>EXPERT PANEL DISCUSSION</u> (Open to attendees)

12:30-2:45	Dr. Robert Bonde, U.S. Geological Survey Mr. Michael Coyne, National Ocean Service Dr. Roger Gentry, National Marine Fisheries Service Dr. Robert Gisiner, Office of Naval Research Dr. Robert Hofman, Marine Mammal Commission Dr. Thomas Jefferson, Ocean Park Conservation Foundation Ms. Barbara Schroeder, National Marine Fisheries Service Dr. Peter Tyack, Woods Hole Oceanographic Institute
2:45-3:00	**Break**
3:00-5:00	**Public Comment**

APPENDIX B

EXPERT PANEL MEMBERS

Dr. Robert Bonde, U.S. Geological Survey

Mr. Michael Coyne, National Ocean Service

Dr. Roger Gentry, National Marine Fisheries Service

Dr. Robert Gisiner, Office of Naval Research

Dr. Robert Hofman, Marine Mammal Commission

Dr. Thomas Jefferson, Ocean Park Conservation Foundation

Ms. Barbara Schroeder, National Marine Fisheries Service

Dr. Peter Tyack, Woods Hole Oceanographic Institute

APPENDIX C

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The Department of the Interior Mission

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 sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; 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 ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.