FWS/OBS-83/03
FEBRUARY 1983

# PROCEEDINGS OF A WORKSHOP ON CETACEANS AND SEA TURTLES IN THE GULF OF MEXICO:

## Study Planning for Effects of Outer Continental Shelf Development



Minerals Management Service
Fish and Wildlife Service
U.S. Department of the Interior

February 1983
FWS/OBS-83/03

# PROCEEDINGS OF A WORKSHOP ON CETACEANS AND SEA TURTLES IN THE GULF OF MEXICO: STUDY PLANNING FOR EFFECTS OF OUTER CONTINENTAL SHELF DEVELOPMENT

Conducted 6-8 April 1982
University of Southern Mississippi
Gulf Coast Regional Campus
Long Beach, MS 39560

Coordinated and edited by

Cherry E. Keller
and
J. Ken Adams
U.S. Fish and Wildlife Service
National Coastal Ecosystems Team
1010 Gause Boulevard
Slidell, LA 70458

Interagency Agreement No. 14-12-001-29118

Sponsored by

Minerals Management Service
Gulf of Mexico OCS Region
P.O. Box 7944
Metairie, LA 70010

## DISCLAIMER

The opinions, findings, conclusions, and recommendations expressed in this report are those of the authors and do not necessarily reflect the views of the U.S. Fish and Wildlife Service, or the Minerals Management Service, nor does the mention of trade names or commercial products constitute endorsement or recommendation by the Federal Government.

This report should be cited as:

Keller, C.E., and J.K. Adams, eds. 1983. Proceedings of a workshop on cetaceans and sea turtles in the Gulf of Mexico: study planning for effects of Outer Continental Shelf development. Prepared by the U.S. Fish and Wildlife Service for the Minerals Management Service, Metairie, LA. 42 pp.

# PREFACE

Both the Minerals Management Service and the Fish and Wildlife Service are concerned that adequate information be available to assess the effects of offshore oil and gas development on endangered and protected vertebrates. The purpose of the workshop was to assemble scientists knowledgeable about cetaceans, sea turtles, and the Gulf of Mexico to discuss the potential impacts of offshore oil and gas development on these animals and make recommendations for future research. The workshop began with brief presentations about the environment of the Gulf of Mexico and the cetaceans and sea turtles found there, and a review of petroleum effects on these animals. Participants then broke into discussion groups to address the following points.

1. Identify ways in which cetaceans and sea turtles have been or could be affected, either directly or indirectly by activities and events associated with offshore oil and gas development.

2. Identify the types and specificity of data needed to predict, detect, and mitigate possible adverse effects.

3. Identify and discuss the advantages and disadvantages of various methods that might be used to obtain needed data.

4. Identify specific research and monitoring programs that would be required to obtain needed data, including the necessary expertise, level of effort, equipment, and facilities.

This report summarizes the presentations and discussions that occurred at the workshop. Discussion sessions were summarized by the chairman and summaries were reviewed by the participants. The discussion summaries reflect the ideas and suggestions made by the participants and have not been filtered or revised according to priorities of the Minerals Management Service or the Fish and Wildlife Service.

Any suggestions or questions about or requests for this report should be directed to:

Information Transfer Specialist
National Coastal Ecosystems Team
U.S. Fish and Wildlife Service
NASA-Slidell Computer Complex
1010 Gause Boulevard
Slidell, LA 70458
(504) 255-6511; FTS 685-6511

CONTENTS

## ACKNOWLEDGMENTS

We would like to thank the Minerals Management Service for its support of the workshop, and Dr. Bob Avent for his help in the initial planning. Ms. Myron Webb and her staff of the University of Southern Mississippi did a superb job in arranging the meeting rooms, meals, and accommodations for participants. Lastly, we would like to thank all the participants for contributing their time and ideas to the goals of the workshop. This workshop was funded by the Minerals Management Service under Interagency Agreement No. 14-12-001-29118.

# SUMMARY OF OPENING REMARKS AND PURPOSE OF WORKSHOP

by
Ken Adams
U.S. Fish and Wildlife Service
National Coastal Ecosystems Team
1010 Gause Boulevard
Slidell, LA 70458

All of the participants were thanked for attending. Gratitude was also expressed to the New Orleans Outer Continental Shelf (OCS) office of the Bureau of Land Management (BLM; now Minerals Management Service) for providing both the incentive and the means for the gathering. Workshop participants were reminded that they were convened to assist the BLM by providing them with a workable plan for gathering needed information. To accomplish this, they were encouraged to participate, to speak out, and to contribute to the effort with the benefit of their special knowledge. It was pointed out that the U.S. Fish and Wildlife Service and BLM were both interested in the biology of cetaceans and sea turtles, as it may be affected by OCS development. Towards satisfying the needs of the BLM leasing program, the following workshop goals were identified:

- Identify ways in which cetaceans and sea turtles have been or could be affected, either directly or indirectly, by activities and events associated with offshore oil and gas development.
- Identify the types and specificity of data needed to predict, detect, and mitigate possible adverse effects.
- Identify and discuss the advantages and disadvantages of various methods that might be used to obtain needed data.
- Identify specific research and monitoring programs that would be required to obtain needed data, including the necessary expertise, level of effort, equipment, and facilities.

The session leaders were then asked to use this statement of goals as a focal point for their discussions, keeping in mind the application of the resultant information to the needs of the Outer Continental Shelf Leasing Program.

KEYNOTE ADDRESSES

# THE GULF OF MEXICO AS AN ECOSYSTEM WITH INTENSIVE PETROLEUM DEVELOPMENT

by

Benny Gallaway
LGL Ecological Research Associates, Inc.
1410 Cavitt Street
Bryan, TX 77801

## SUMMARY

The Texas-Louisiana shelf ecosystem in the Gulf of Mexico was described (1) in terms of its physiographic, oceanographic, and biological characteristics and (2) as a recipient of oil and gas development activities and effluents. The northeast sector of the ecosystem is influenced by Mississippi River discharge, whereas high-salinity Caribbean water affects the southwest sector. Soft-bottom communities are prominent, characterized by economically valuable penaeid shrimps. The coral reef communities, because of their uniqueness and scarcity, are more important than would normally be assumed. Pelagic communities are little known and harbor only a few commercially valuable species. It is surmised that much of the primary productivity from the pelagic community is used by the bottom communities.

Observed effects of oil and gas development activities and effluent were described. Data from most field studies indicate that direct effects are limited in space, but the effects over time are unknown. One of the major problems has been separating effects of oil and gas development-related activities and other man-induced variations from natural changes. Of particular concern are increased organic loading of the system and the apparently related low dissolved oxygen levels characteristic of some parts of the system during warm seasons. It was recommended that future research be directed towards defining key processes governing the ecosystem, with modeling workshops serving as the focus for these research and monitoring programs.

# DISTRIBUTION OF CETACEANS AND SEA TURTLES IN THE GULF OF MEXICO AND NEARBY ATLANTIC WATERS

by

Thomas Fritts
U.S. Fish and Wildlife Service
Museum of Southwestern Biology
University of New Mexico
Albuquerque, NM 87131

The objective of any environmental planning is to avoid or minimize effects on populations. In most cases, effects on individual organisms are tolerated if the overall effect on the population is not significant. Inherent in being able to detect or predict environmental effects on populations is an understanding of the ecology and population structure of the species involved. Such an understanding is often lacking when environmental questions are asked.

A few years ago, had someone forced us to provide an educated guess as to where in the Gulf of Mexico a significant number of sperm whales might come in contact with oil products, we would have had to answer with general comments about the deep areas of the eastern Gulf where most whaling records and incidental sightings had occurred. We would have been ignorant of significant numbers of sperm whales off south Texas and the potential for studying the movements, population structure, and ecology of this species in the western Gulf of Mexico where major oil and gas activities are concentrated.

Similarly, if someone had asked us to identify a major feeding area for the loggerhead turtle, the major concentrations in the eastern Gulf of Mexico might have been given minimal consideration because the area had been poorly studied. However, data at present suggest that the broad shelf and relatively undisturbed areas off southwestern Florida furnish habitat for large numbers of loggerhead and other marine turtles.

In order to gain a better understanding of vertebrate populations in the Gulf of Mexico and adjacent waters of the Atlantic Ocean, the Bureau of Land Management and the Fish and Wildlife Service initiated a study in 1979. The purpose was to study geographic, seasonal, and ecological variation in distribution and abundance. The results, although based on only slightly more than a one-year field period, contribute to our ability to find, evaluate, and understand populations important to the study of oil and gas effects related to leasing of Outer Continental Shelf areas.

## MARINE MAMMALS

Three groups of cetaceans that are primarily restricted to waters deeper than 200 m (sperm whales, beaked whales, and pilot whales) were observed in the western Gulf of Mexico off south Texas. The data on sperm whales and beaked whales were particularly valuable because these groups are poorly known in the Gulf of Mexico. The presence of Risso's dolphin in the western gulf was also noteworthy. Short-finned pilot whales were most common off the Atlantic coast of Florida, but were noted in a narrow zone over waters about 350 m deep off south Texas. The color pattern noted in sightings of short-finned pilot whales may facilitate distinguishing the species from long-finned pilot whales during aerial and shipboard studies. Baleen whales are poorly studied in the Gulf of Mexico.

Many questions remain with regard to small odontocetes. Bottlenose dolphins appear to be distributed at large distances from shore where the Continental Shelf is broad and restricted to narrow coastal bands when the shelf is narrow. In contrast to bottlenose dolphins, the distribution of striped and spotted dolphins (Stenella spp.) is less obviously correlated with bathymetry. As an example, both of the Stenella species were observed in moderately shallow waters and in greater numbers in the area off southwest Florida than in other areas. Spinner dolphins were also detected and these records amplify the previous distribution based on stranding and meager museum records. The ecology and movements of these and other dolphins are not sufficiently understood to evaluate impacts related to OCS development.

## MARINE TURTLES

The status of our knowledge of marine turtles was formerly based on fisheries data, strandings, and observations made on nesting beaches. The present data augment this knowledge by providing information about their ecology at sea.

More than 97% of all sightings of loggerhead and leatherback turtles were off eastern and western Florida. A paucity of turtles of all species was reported in waters off Louisiana and Texas. The majority of Kemp's ridley turtles was observed off western Florida, but even there the numbers of this endangered turtle were relatively low.

The year-round presence of marine turtles in waters off Florida was conspicuous, suggesting that if winter dormancy occurs, turtles periodically surface, allowing detection. Although the frequency of sightings decreased seasonally, the decrease occurred prior to major lowering of sea surface temperatures and increased prior to the major elevation of sea surface temperatures.

The distribution of loggerhead turtles appeared to be strongly influenced by bathymetry. Loggerheads occurred on the narrow coastal shelf off Cape Canaveral (eastern Florida), but were over 200 km from shore on the broad shelf off southwestern Florida.

Leatherback turtles were also recorded predominantly on the Continental Shelf and only infrequently in deeper waters where previously they were presumed to occur.

## SUMMARY

In summary, the major mammal populations in the south Texas area were forms predominantly distributed off the Continental Shelf. Bottlenose dolphins were present in all areas studied, but their range was strongly linked to bathymetric contours. The numbers of bottlenose dolphins and Stenella (spinner, spotted, and striped) dolphins were relatively high in the area off southwestern Florida. The Atlantic coast of Florida was unique in having right whales and other transient or migrant cetacean species.

The major concentrations of marine turtles were observed in waters off Florida. The area off southwestern Florida is exceptional in having large numbers of turtles and low levels of nesting in relation to eastern Florida. The role of these "feeding" habitats in the recovery or continued decline of marine turtles in continental U.S. waters remains to be studied.

# OVERVIEW OF THE EFFECTS OF PETROLEUM DEVELOPMENT ON CETACEANS

by

David J. St. Aubin
Department of Pathology
Ontario Veterinary College
University of Guelph
Guelph, Ontario
N1GZW1, Canada

## SUMMARY

The development of offshore oil and gas reserves presents a number of potential threats to marine mammals. Seismic surveys employing various high explosives can be lethal at close range. Noise is associated with all phases of petroleum exploration and production. The physical, physiological, and behavioral effects of noise disturbance on marine mammals are poorly understood and need to be investigated.

Exposure to spilled oil has been implicated as the cause of death of pinnipeds and cetaceans; however, much of the evidence has been inconclusive. Surface contact is threatening to those species which rely on hair or fur for thermal insulation, such as sea otters, fur seals, and polar bears. Though cetaceans are not likely to accumulate oil on their body surfaces, the unique metabolic and physiologic properties of cetacean skin may be impaired by toxic fractions in crude oil. Preliminary results, however, indicate cetacean skin is not very sensitive to crude oil. Marine mammals are unlikely to ingest sufficient quantities of oil to cause acute toxicity. However, the long-term effects of accumulation of petroleum fractions through the food chain are unknown. Inhalation of toxic vapors would occur in any oil spill situation and can be life threatening in the case of prolonged exposure. The ability of marine mammals to detect and avoid oil slicks is critical to any assessment of the potential impact of oil, and yet such information is lacking.

This review summarized field observations and experimental studies of the effects of oil and oil exploration on marine mammals, identified gaps in our knowledge, and established priorities for future research.

# A REVIEW OF SOME PETROLEUM IMPACTS ON SEA TURTLES

by

Ross Witham
Florida Department of Natural Resources
P.O. Box 841
Jensen Beach, FL 33457

There is evidence that oil fouling harms small sea turtles. Witham (1978) reported the deaths of two small Chelonia mydas (carapace lengths 7.5 and 10.2 cm) and the apparent rehabilitation of a 31.8-cm carapace length C. mydas fouled with oil. The smallest of these had been covered by oil, while the others had apparently tried to ingest tar. An additional 27 small sea turtles of three species were handled for oil or tar impact since 1978: loggerhead sea turtles (Caretta caretta), green sea turtles (C. mydas), and hawksbill sea turtles (Eretmochelys imbricata) (unpublished data, Florida Department of Natural Resources, Marine Research Laboratory, St. Petersburg, Florida). Of the smaller turtles, 16 died and 11 were rehabilitated. A larger C. caretta (56.6 cm) was observed to have a small amount of tar in its mouth, but appeared to be unaffected.

All effects of petroleum fouling on turtles are not known. However, weathered petroleum (tar) sealed the mouths and nostrils of small turtles examined. Impacted turtles can be cleaned by removing the petroleum with vegetable oil or a soapless hand cleaner followed by thorough rinsing. This procedure resulted in rehabilitation of some tar-impacted turtles, but all oiled turtles died. Long-term survival is not assured by such cleansing; turtles should be held until they are active and feeding. Post cleansing rehabilitation may require dosing with a mild laxative (milk of magnesia), forced feeding, and vitamin supplements.

Petroleum residues are widespread in the marine environment (Blumer 1969; Butler et al. 1973). Physical, chemical, and biological activity (Nelson-Smith 1973) alters spilled oil. Tar residue may float for as long as a year (Dedra 1977). Van Vleet et al. (in MS.) reported that the North Atlantic receives about 7,000 metric tons of pelagic tar annually from the Loop Current. All petroleum-impacted turtles have been found from the Keys to Cape Canaveral, an area closely associated with the Florida Current. The majority of these turtles were found during periods of prolonged, strong easterly winds.

The apparent widespread dispersal of young sea turtles (Witham and Futch 1977; Witham 1980), accompanied by the known widespread dispersal of petroleum residues, suggests that indeterminate numbers of small sea turtles may be dying at sea. Aerial surveyors (Anonymous 1981) detect only larger turtles; the smaller ones are uncounted. Drift bottle data (Williams et al. 1977) suggest that most young turtles dying at sea would not be washed up on beaches.

Kleerekoper and Bennett (1976) suggested that small sea turtles may be chemoresponsive to petroleum. Tar ingestion may result from a visual feeding response. Laboratory studies could help to clarify these responses.

## LITERATURE CITED


Anonymous. 1981. Distribution and abundance of endangered and vulnerable mammals, birds and turtles of the Gulf of Mexico and South Atlantic OCS. In First ternary eastern Gulf of Mexico studies meeting. BLM OCS ESP, Oct. 15 and 16, 1981, New Orleans, La.; unpaginated.

Blumer, M. 1969. Oil pollution of the ocean. Pages 5-13 in D.P. Hoult, ed. Oil on the sea. Plenum Press, New York.

Butler, J.N., B.F. Morris, and J. Sass. 1973. Pelagic tar from Bermuda and the Sargasso Sea. Bermuda Biological Station for Research, Special Publication No. 10.

Dedra, D. 1977. The disasters that didn't. Pages 11-15 in EXXON, USA, 3rd qrt.

Kleerekoper, H., and J. Bennett. 1976. Some effects of the water soluble fraction of Louisiana crude on the locomotor behavior of juvenile green turtles (Chelonia mydas) and sea catfish (Arius felis). Preliminary results. Abstract presented at the NOAA symposium on the fate and effects of petroleum hydrocarbons in marine ecosystems and organisms. Nov. 10-12, 1976. Seattle, Wash.

Nelson-Smith, A. 1973. Oil pollution and marine ecology. Plenum Press, New York. 260 pp.

Van Vleet, E.S., W.M. Sackett, F.F. Weber, Jr., and S.B. Rinhardt (In MS.). Input of pelagic tar into the Northwest Atlantic from the Gulf Loop Current: chemical characterization and its relationship to weathered IXTOC-I oil. Submitted to Can. J. Fish. Aquat. Sci.

Williams, J., W.F. Grey, E.B. Murphy, and J.J. Crane. 1977. Drift bottle analyses of eastern Gulf of Mexico surface circulation. Memoirs, Hourglass Cruises IV(III) Department of Natural Resources, Marine Research Laboratory, St. Petersburg, Fla. 134 pp.

Witham, R. 1978. Does a problem exist relative to small sea turtles and oil spills? Pages 62-632 Am. Inst. Biol. Sci. in Proceedings of a Conference on the assessment of ecological impacts of oil spills, 14-17 June 1978. Keystone, Colo.

Witham, R. 1980. The "lost year" question in young sea turtles. Am. Zool. 20: 525-530.

Witham, R., and C.R. Futch. 1977. Early growth and oceanic survival of pen-reared sea turtles. Herpetologica 33:404-409.

# RESULTS OF WORKING GROUP SESSIONS

## CETACEAN WORKING GROUP RESULTS

## DISTRIBUTION AND ABUNDANCE STUDIES OF CETACEANS IN THE GULF OF MEXICO, SUMMARY REPORT

Howard E. Winn, Working Group Chairman
Graduate School of Oceanography
University of Rhode Island
Kingston, RI 02881

and

Peter F. Major, Working Group Co-Chairman
Marine Mammal Commission
1625 I. St., NW
Washington, DC 20006

### OBJECTIVES

The charge to the group was to identify (1) direct and indirect effects of Outer Continental Shelf developmental activities on the distribution of cetaceans in the Gulf of Mexico; (2) the information known about the distribution and abundance of cetaceans in the gulf; (3) the data gaps concerning cetacean distribution and abundance and existing and planned Outer Continental Shelf oil and gas development; (4) methodologies to be considered, their advantages and disadvantages, and when and where such methods could be used; and (5) what research programs or projects have been, are, and should be considered to acquire the information needed by the Bureau of Land Management for their decisionmaking process and to monitor the possible effects of oil and gas development on cetacean distribution and abundance in the Gulf of Mexico.

### SPECIES

A list of the species of cetaceans found or thought to occur in the Gulf of Mexico based on various historical records is provided in Table 1. Other than recent surveys by Dr. T. Fritts (see list of current research) there have been no systematic investigations of the distribution and abundance of offshore species of cetaceans in the Gulf of Mexico. Individual in-depth studies and systematic surveys of bottlenose dolphins close to shore or in bays and estuaries throughout the gulf are largely conducted for the National Marine Fisheries Services (NMFS).

Much of the "historical" record of the identity of large cetacean species occurring offshore in the Gulf of Mexico (especially sperm whales) is derived

from strandings and whalers' logbooks. The consensus of the group was that historical records identifying baleen whales may in many instances be questionable, and that baleen whales in the gulf may be rare and/or transient. Nevertheless, strandings do occur and sightings have been made. Surveys have not been thorough or complete enough to determine with confidence the identification or nature and extent of the presence of baleen whales in the gulf. A hypothesis was put forth that if there were resident baleen whales in the gulf, Balaenoptera edeni (Bryde's whale) would be the most likely species, largely because "a population" does occur to the south in and/or near the Caribbean area. Sperm whales definitely do occur throughout the year in the gulf according to whalers' records and recent surveys by T. Fritts. These whales appear to occur predominantly outside the 200 to 1,000-m "drop off." Because there has not been individual whale identification of sperm whales in the gulf, nothing can be said about the discreteness of "the population," the whales' residency, or movements in the gulf.

Table 1. Cetaceans of the Gulf of Mexico (adapted from Schmidly 1981).

Order Cetacea
- Suborder Mysticeti - Baleen whales
  - Family Balaenidae - Right whales
    - Eubalaena glacialis - Right whale
  - Family Balaenopteridae - Rorquals
    - Balaenoptera musculus - Blue whale
    - Balaenoptera borealis - Sei whale
    - Balaenoptera physalus - Fin whale
    - Balaenoptera edeni - Bryde's whale
    - Balaenoptera acutorostrata - Minke whale
    - Megaptera novaeangliae - Humpback whale
- Suborder Odontoceti - Toothed whales
  - Family Physeteridae - Sperm whales
    - Physeter catodon - Sperm whale
    - Kogia breviceps - Pygmy sperm whale
    - Kogia simus - Dwarf sperm whale
  - Family Ziphiidae - Beaked whales
    - Mesoplodon densirostris - Blainville's beaked whale
    - Mesoplodon europaeus - Gervais' beaked whale
    - Ziphius cavirostris - Cuvier's beaked whale
  - Family Delphinidae - Dolphins
    - Feresa attenuata - Pygmy killer whale
    - Pseudorca crassidens - False killer whale
    - Orcinus orca - Killer whale
    - Globicephala macrorhynchus - Short-finned pilot whale
    - Steno bredanensis - Rough-toothed dolphin
    - Delphinus delphis - Common dolphin
    - Tursiops truncatus - Bottlenose dolphin
    - Grampus griseus - Risso's dolphin
    - Stenella frontalis - Bridled dolphin
    - Stenella plagiodon - Atlantic spotted dolphin
    - Stenella coeruleoalba - Striped dolphin
    - Stenella longirostris - Spinner dolphin
    - Stenella clymene - Short-snouted spinner dolphin

Discussion of the distribution and abundance of "small" cetaceans other than bottlenose dolphins in the Gulf of Mexico must await the publication of the results of T. Fritts' survey work. A confounding problem, however, is that a number of the species that are known from verified strandings were not observed by T. Fritts' survey personnel. In addition, some of the species, even those observed in some abundance during the surveys, are very rare or do not occur in the stranding record.

The best understood cetacean species in the gulf is the bottlenose dolphin. However, very little information is known about the discreteness of the small "local" groups in various inshore locations along the gulf coast, how much interaction occurs between these groups, and the nature and extent of relationships between bottlenose dolphins found in inshore waters and those animals that have been observed "offshore." Abundance estimates are being calculated for bottlenose dolphins in specific areas of the gulf by the NMFS (see References for previously published studies).

## OIL AND GAS DEVELOPMENT ACTIVITIES AFFECTING THE DISTRIBUTION AND ABUNDANCE OF CETACEANS IN THE GULF

The Gulf of Mexico, or at least the north-central section of the gulf, is considered a developed area (as compared to a frontier area) with respect to OCS oil and gas development. At the time of this workshop, nothing is known about the effects of offshore oil and gas development on cetacean distribution and abundance in the gulf. In fact, as previously pointed out, little is known about cetaceans in the gulf. Therefore, cause and effect relationships, whether short- or long-term, cannot be specified. Still, ongoing and planned field and laboratory experiments may provide some insight into what might be anticipated if previously undeveloped gulf areas become developed (e.g., off the west coast of Florida). Adverse effects might originate from any or all activities associated with each of the major OCS oil and gas developmental stages (e.g., pre-drilling exploration, exploration, production phases including drilling, support and storage, transportation). Possible changes in the distribution and abundance of cetaceans as populations are mediated via the sensory pathways of individuals and their subsequent behavior (i.e., movement). Studies being conducted or being planned in other geographic areas on species that may or may not occur in the gulf may provide insight into potential effects of developmental activities on species that do occur in the gulf. Studies of bowhead whales in the Arctic, humpback whales in Glacier Bay, and gray whales along the west coast may provide general information about the effects that the presence of offshore structures, acoustic stimuli, visual stimuli, and the abundance and distribution of prey have on the distribution, abundance, and movements (short-term) of large baleen species. Such information may be applicable to the gulf or indicate types of studies that can be undertaken on sperm whales and small cetaceans. In addition, studies on the effects of oil on small cetaceans (and baleen fouling) by Geraci and St. Aubin and others might similarly be considered. Many potential effects have been previously identified in other workshop reports (e.g., Prescott et al. 1980) or papers (e.g., Geraci and St. Aubin 1980).

### Information Needs

As previously stated, relatively little systematic knowledge has been collected about the identification, distribution, and abundance of large and

small cetaceans (except bottlenose dolphins) in the Gulf of Mexico. The surveys being undertaken by T. Fritts have not been comprehensive enough to provide with confidence an inventory of cetacean species and their relative abundance. Survey sample areas were not or could not be extended in all areas beyond the 200 to 1,000-m drop-off, which occurs at a considerable distance offshore in some areas (e.g., off southwest Florida).

A number of suggestions were made with respect to sample design for survey programs. These include extending tacklines in areas presently being surveyed father offshore (beyond the 200 to 1,000-m drop-off either continuously or discontinuously) so that deep-water species might be observed. In addition, bathemetry, current patterns, stranding records, and productivity information indicate that surveys for particular baleen whales might be undertaken to the east of the Mississippi River Delta area extending sufficiently far offshore to provide some confidence about the identity and distribution of the deep water species. "Baseline" data do not exist except for bottlenose dolphins, sperm whales, and one or more species of Stenella. Information on daily, seasonal and/or annual occurrence is needed on many species. The ability to predict and mitigate any effect of oil and gas development on cetacean distribution and abundance must rely initially upon established baselines. Specific methods of detecting effects and consequent changes in distribution and abundance will be addressed in the other workshop sections.

## Methods

A variety of methods can be and have been used to study the distribution and abundance of cetaceans.

Aerial surveys. Aerial surveys have predominated in cetacean studies to date in the Gulf of Mexico. Specific methods, their advantages, and disadvantages have been addressed in other forums and the open literature (e.g., Eberhardt et al. 1979). Aerial surveys in the gulf can be characterized as intense surveys of discrete areas rather than comprehensive or gulf-wide. Predictive surveys on a seasonal and/or annual basis have been made in some areas. Such surveys have been previously mentioned (e.g., see list of ongoing research; References).

Behavioral and ecological studies of bottlenose dolphins in specific areas off Florida and Texas have been and may continue to be conducted (e.g., see Asper and Odell 1980; Shane 1980; Wells et al. 1980; Gruber 1981). These studies may also provide information about the distribution, relative abundance, and movements of this species.

Acoustic monitoring techniques. Techniques such as deployment of passive listening hydrophones, drifting or anchored sonobuoys, and hydrophones attached to existing weather buoys may be relatively inexpensive methods of collecting cetacean distribution information. Hydrophones could be deployed in areas through which migratory species might pass or in areas where presence is suspected, which cannot be surveyed as frequently as desired. Satellite links with hydrophones or recording hydrophones that can be serviced at periodic intervals should be considered. Such hydrophones may be either omni- or unidirectional; but simple presence information might best be collected from omnidirectional equipment.

Platforms of opportunity. The use of platforms of opportunity is another technique to collect qualitative and possibly some quantitative information about the distribution of cetaceans. Existing oil/gas platforms; research, commercial, fishing, oil/gas transportation vessels; and aircraft can provide a means for "surveying" specific areas for cetaceans. At present these opportunities appear to be under-utilized in the gulf area. The primary advantage of this method is that presence location, identification, and perhaps relative abundance information can be collected relatively inexpensively. Management of a platforms-of-opportunity program and analysis of observational effort and data may be difficult.

Stranded cetaceans. Stranded cetaceans have provided the bulk of historical information about the occurrence and distribution of cetaceans in the gulf. A stranding network (centered at the University of Miami) has been functioning for several years with support from the NMFS. To be effective, adequate information must be distributed throughout the coastal area covered by the network; individuals and organizations must be responsive to strandings (i.e., proper records and reports must be made in a timely manner); and sufficient resources must be available for the collection, preservation, storage, analysis, and distribution of specimens, tissues, and data. As pointed out above, verification of stranded species has often been difficult and can still be a problem. In addition, some stranded species have not been observed offshore while other species that do occur offshore seldom or never strand. The distribution of beached animals may be unrelated to their normal offshore distribution (e.g., stranded animals may depart from areas usually occupied prior to stranding, or currents or seas may deposit animals that are dead or weak in certain areas and not others).

Cetaceans taken incidental to fishing operations. These may also provide information about the distribution of species in the gulf. Little is known about how many cetaceans are caught by fishermen using gill nets, seines, hook and line, etc., in the gulf.

Recognition of individuals. This is becoming an important means of understanding a species' or population's short- and long-term (daily, seasonal, annual) distribution, abundance, movements, and use of specific geographical areas. Individuals of some cetacean species have natural marks permitting at least short-term discrete monitoring of their movements and behavior. Individuals of other species apparently do not have visible natural marks, at least of the kind that can be used reliably at a distance. The use of tags (e.g., visible, radio, sonic, satellite) are particularly valuable in providing, at least in some instances, continuous monitoring of individuals within groups or populations. Tagging studies of bottlenose dolphins in the Southeastern United States by Asper and Odell (1980), Wells et al. (1980), Irvine et al. (1981b), and of other cetaceans (e.g., killer whales, gray whales, Stenella) provide examples of the usefulness of such techniques in determining the distribution and relative abundance of cetaceans in local areas and their long distance movements. An assumption of using data collected from a few tagged individuals is that such data are representative of the population as a whole. Continuous recordings of the individuals, providing larger sample sizes of certain kinds of data, may make monitoring of marked individuals possible

before, during, and after their exposure to OCS oil/gas development activities. Following a small number of tagged individuals may provide sufficient data (with which one may have some confidence) to determine cause and effect relationships. In addition, the use of natural or artificial markers will allow investigators an opportunity to return periodically to sample these same individuals over both short and long periods of time, a critical need in long-term monitoring studies.

Satellites (remote sensing). Satellites may prove to be an important tool in understanding the distribution and perhaps abundance of cetaceans in the gulf. As indicated above, satellites might be used indirectly to determine the presence of cetaceans (through the use of hydrophones) or for tracking individual animals (use of radiotags). The Coastal Zone Color Scanner (CZCS) of the National Oceanic and Atmospheric Administration might be used to determine areas of chlorophyll concentration (productivity) and possibly fish schools. Observations of cetaceans during aerial or shipboard surveys during periods when the CZCS is passing over the gulf may be of special importance. The utility and importance of satellites in relating environmental variables with the distribution and occurrence of marine vertebrates are starting to be documented (e.g., Lasker et al. 1981). Potential disadvantages of the use of satellites are their limited duration over a study area (unless a satellite is in geosynchronous orbit) and the synoptic nature and resolution of information acquired. Thus, continuous records of the movement of tagged individuals cannot be obtained, but daily, seasonal, and annual (discrete) data points can be obtained within the area scanned by a satellite.

## Integrated Studies

A number of studies have been, are being, and may be undertaken by reseachers under contract to one or more Federal agencies. It was indicated at the meeting that these studies were not well coordinated. In fact, there has been almost no interaction, at least in the planning and design of studies, between and among agencies and principal investigators. This lack of cooperation and coordination is particularly evident in surveys of bottlenose dolphins inshore and the more general offshore cetacean (and turtle) studies.

## SUGGESTIONS AND RECOMMENDED RESEARCH AND MONITORING PROGRAMS

The following recommendations or suggestions were made by workshop participants (not in order of priority):

(1) Systematic Surveys

(a) Continue aerial surveys so that areas are adequately covered seasonally and over at least an initial period of 3 years. Areas previously surveyed should cover waters beyond the 200 to 1,000-m "drop-off" of the continental slope; areas east of the Mississippi River Delta should also be surveyed. The identification of any additional areas should take into account submarine topography, upper-water productivity, and research being undertaken or supported by other agencies.

(b) Related to the above are surveys along the 200 to 1,000-m shelf slope to determine what species occur in the area. As indicated above, extending present survey areas farther offshore may be sufficient to provide an indication of the kinds and numbers of cetaceans in these waters. Extension of the survey areas off Florida and Louisiana should be considered. The survey area off Texas appears to provide reasonable coverage of deep-water areas.

(c) Of particular importance may be the continuation and possible expansion of the NMFS-sponsored surveys for bottlenose dolphins with resurveys at periodic intervals in areas of the gulf previously studied. A high priority should be given to studies in areas having oil/gas development as well as undeveloped areas. The areas should also include inshore and offshore regions. These considerations may require some amount of coordination and cooperation between the National Marine Fisheries Service, the Minerals Management Service and contract investigators.

These systematic survey projects should be continued at periodic intervals to monitor the possible effects of oil/gas development on the distribution of cetaceans, particularly where adequate baseline information has been or can be acquired in areas not now under production.

(2) Qualitative sampling programs

The following programs can provide important qualitative and occasional quantitative data on the occurrence, distribution, and abundance of cetaceans.

(a) Support of the southeast stranding program should be continued and increased to allow improved coverage and for analysis of the archieved data. This becomes increasingly important with the loss of the Smithsonian Event Alert Network (SEAN). Information acquired through this program benefits a number of agencies, including MMS and may best be supported as an interagency cooperative project.

(b) Platforms of opportunity exist in great abundance and variety within the gulf, and the use of the vessels, aircraft, and oil rigs should be thoroughly investigated.

(c) Hydrophones (omnidirectional) may be a method to collect information about the presence of cetaceans in specific areas. Equipment that records data or relays them to a satellite, vessel, aircraft, or shore stations may be useful in areas not surveyed or when surveys cannot be conducted.

(3) Radio and Sonic Tagging of Individual Cetaceans

The tagging and tracking of individuals is an important means of adequately documenting and understanding the relationship between distribution of individual cetaceans and possible effects that oil/gas development may have on their short and long-term movements. Study areas should take into consideration developed and presently undeveloped areas and should meet the needs of both NMFS and MMS.

(4) Remote sensing

Satellites and high altitude aircraft sensing of environmental variables (chlorophyll, temperature, fish schools, etc.) may provide information about the environmental context within which cetaceans occur. However, ground-truthing of the environmental data and the distribution of cetaceans must occur using vessels and low-level aircraft. Remote sensing might provide a means of providing synoptic data to monitor the environmental changes that occur as oil/gas activities move into areas not currently being developed. Indirectly these data may then be used to establish hypotheses and to identify areas to investigate effects of oil/gas development on cetacean distribution and abundance.

SUMMARY

Systematic surveys are the only means of quantifying the presence of species and extent of their occurrence over wide geographical areas. Such surveys must be made frequently enough to identify the daily, seasonal, and annual use of habitats that may be of some importance (e.g., for feeding, reproducing) to species of cetaceans in the gulf.

Radio tagging/tracking of individual cetaceans should provide similar quantitative information of a limited number of individuals, which may be representative of populations as a whole. The marking and tagging of individuals and the subsequent monitoring of these individuals at periodic intervals over the lifespan of the development of an area should be given high priority.

Strandings, platforms of opportunity, hydrophones and satellites are all means by which qualitative information can be acquired relatively inexpensively over a long period of time, i.e., they may be techniques to monitor the general distribution and occurrence of cetaceans. The southeastern stranding network should be continued and expanded, and remote sensing methods and platforms of opportunity should be used effectively.

Given the lack of available quantitative information on many of the cetacean species thought or known to occur in the gulf, investigations should focus on the following species at least until adequate basic information is acquired on other species:

Small cetaceans

(1) Bottlenose dolphins Tursiops truncatus (inshore/nearshore)
(2) One or more Stenella species (offshore)

Large cetaceans

(3) Sperm whales (offshore)
(4) Baleen whales (perhaps Balaenoptera edeni) (offshore?)

Any studies that are planned and undertaken should be coordinated; should adequately address simultaneously the needs of appropriate Federal and State agencies; and should include representative "sampling" from areas previously or currently under development, areas in which development is anticipated in the future, and areas that may always remain "pristine."

## REFERENCES


Asper, E.D., and D.K. Odell. 1980. Tursiops truncatus studies: bottlenose dolphin local herd monitoring -- capture, marking, collection of biological data, and follow-up observations of marked animals. Final report for NMFS contract NA79-GA-C-00027.

Eberhardt, L.L., D.G. Chapman, and J.R. Gilbert. 1979. A review of marine mammal census methods. Wildl. Monogr. No. 63. 46 pp.

Fritts, T., and R. Reynolds. Pilot study of the marine mammals, birds and turtles in OCS areas of the Gulf of Mexico. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C. FWS/OBS-81/36.

Geraci, J.R., and D.J. St. Aubin. 1980. Offshore petrolem resource development and marine mammals: a review and research recommendations. Mar. Fish. Rev. Nov.:1-12.

Gruber, J.A. 1981. Ecology of the Atlantic bottlenosed dolphin (Tursiops truncatus) in the Pass Cavallo area of Matagorda Bay, Texas. M.S. Thesis. Texas A&M University, College Station. 181 pp.

Irvine, A.B., M.D. Scott, R.S. Wells, J.H. Kaufmann, and W.E. Evans. 1979. A study of the activities and movements of the Atlantic bottlenosed dolphin, Tursiops truncatus, including an evaluation of tagging techniques. Final report for MMC contracts MM4AC004 and MM5AC018. U.S. Dep. Commerce, Natl. Tech. Info. Serv. PB 298 042. 54 pp.

Irvine, A.B., J.E. Caffin, and H.I. Kochman. 1981a. Aerial surveys for manatees and dolphins in western peninsular Florida: with notes on sightings of sea turtles and crocodiles. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C. FWS/OBS-80/50. 20 pp.

Irvine, A.B., M.D. Scott, R.S. Wells, and J.H. Kaufmann. 1981b. Movements and activities of the Atlantic bottlenose dolphin, Tursiops truncatus, near Sarasota, Florida. U.S. Natl. Mar. Fish. Serv. Fish. Bull. 79:671-688.

Irvine, A.B., R.S. Wells, and M.D. Scott. 1982. An evaluation of techniques for tagging small odontocete cetaceans. U.S. Natl. Mar. Fish. Serv. Fish. Bull. 80:135-143.

Lasker, R., J. Pelaez, and R.M. Laurs. 1981. The use of satellite infrared imagery for describing ocean processes in relation to spawning of the northern anchovy (Engraulis mordax). Remote Sens. Environ. 11:439-454.

Lear, R.J., and M.M. Bryden. 1980. A study of the bottlenose dolphin Tursiops truncatus in eastern Australian waters. Occas. Pap. 4. Aust. Natl. Parks Wildl. Serv., Canberra. 22 pp.

Leatherwood, S. 1975. Some observations of feeding behavior of bottle-nosed dolphins (Tursiops truncatus) in the northern Gulf of Mexico and (Tursiops cf. T. gilli) off southern California, Baja California, and Nayarit, Mexico. Mar. Fish. Rev. 37(9):10-16.

Leatherwood, S. 1978. Aerial survey of the bottlenosed dolphin, Tursiops truncatus, and the West Indian manatee, Trichechus manatus, in the Indian and Banana Rivers, Florida. U.S. Natl. Mar. Fish. Serv. Fish. Bull. 77:47-59.

Leatherwood, S., and I.T. Snow. 1980. Development of systematic procedures for estimating sizes of population(s) of bottlenose dolphins and estimates of sizes of population(s) of bottlenose dolphins in three geographical areas; with incidental observations on densities of West Indian manatees and marine turtles. Final report for NMFS contract NA79-GA-C-0038.

Leatherwood, S., J.R. Gilbert, and D.G. Chapman. 1978. An evaluation of some techniques for aerial censuses of bottlenosed dolphins. J. Wildl. Manage. 42(2):239-250.

Leatherwood, S., M.W. Deerman, and C.W. Potter. 1978. Food and reproductive status of nine Tursiops truncatus from the Northeastern United States coast. Cetology No. 28:1-6.

Mead, J.G. 1975. Preliminary report on the former net fisheries for Tursiops truncatus in the western North Atlantic. J. Fish. Res. Board Can. 32:1155-1162.

Norris, K.S., and T.P. Dohl. 1980. The structure and functions of cetacean schools. Pages 211-261 in L.M. Herman, ed. Cetacean behavior: mechanisms and functions. John Wiley and Sons, Inc., New York.

Odell, D.K. 1975. Status and aspects of the life history of the bottlenose dolphin, Tursiops truncatus, in Florida. J. Fish. Res. Board Can. 32:1055-1058.

Odell, D.K. 1979. A preliminary study of the ecology and population biology of the bottlenose dolphin in southeast Florida. Final report for MMC contract MM4AC003. U.S. Dep. Commerce, Natl. Tech. Info. Serv. PB 294 336. 26 pp.

Odell, D.K., and J.E. Reynolds, III. 1980. Abundance of the bottlenose dolphin, Tursiops truncatus. Final report for MMC contract MM5AC021. U.S. Dep. Commer., Natl. Tech. Info. Serv. PB 291 161. 141 pp.

Prescott, J.H., S.D. Kraus, and J.R. Gilbert. 1980. East coast/gulf coast cetacean and pinniped research workshop. U.S. Dep. Commer., Natl. Tech. Info. Serv. PB80-160104. 142 pp.

Ridgway, S.H., and K. Benirschke, eds. 1977. Breeding dolphins: status, suggestions for the future. Final report for MMC contract MM6AC009. U.S. Dep. Commer., Natl. Tech. Info. Serv. PB 273 673. 308 pp.

Schmidly, D.J. 1981. Marine mammals of the Southeastern United States coast and the Gulf of Mexico. FWS/OBS-80/41. U.S. Gov. Print. Office, Washington, D.C. 165 pp.

Schmidly, D., and S.H. Shane. 1978. A biological assessment of the cetacean fauna of the Texas coast. Final report for Marine Mammal Commission contract MM4AC008. Natl. Tech. Info. Serv. PB 281 763. 38 pp.

Shane, S.H. 1980. Occurrence, movements, and distribution of bottlenose dolphin, Tursiops truncatus, in southern Texas. U.S. Natl. Mar. Fish. Serv. Fish. Bull. 78:593-602.

Walker, W.A. 1981. Geographical variation in morphology and biology of bottlenose dolphins (Tursiops) in the eastern North Pacific. Draft report to the NMFS under contract 03-7-208-35238.

Wells, R.S., A.B. Irvine, and M.D. Scott. 1980. The social ecology of inshore odontocetes. Pages 263-317 in L.M. Herman, ed. Cetacean behavior: mechanisms and functions. John Wiley & Sons, New York.

Wells, R.S., M.D. Scott, A.B. Irvine, and P.T. Page. 1981. Observations during 1980 of bottlenose dolphins, Tursiops truncatus, marked during 1970-1976, on the west coast of Florida. Final report for NMFS contract NA80-GA-A-195.

List of Ongoing Marine Mammal and Turtle Research Projects in the Gulf of Mexico and South Atlantic Coast of United States (principal investigator in parentheses)

National Marine Fisheries Service

1. Aerial surveys in the following areas:

| Location | Dates of Surveys | Number of Surveys |
|---|---|---|
| Indian-Banana Rivers, Florida | November 1979; January, May, August and November 1980 | 5 |
| Tampa Bay, Florida | September, November 1979 | 2 |
| Charlotte Harbor, Florida | January, April, July, and October 1980 | 4 |
| Apalachicola-St. Joseph's Bays, Florida | June, September, and December 1980; March 1981 | 4 |
| Mississippi Sound, Mississippi | June, September, and December, 1980; March 1981 | 4 |
| Aransas-Copano-San Antonio Bays, Texas | May, August, November 1980; February 1981 | 4 |
| Laguna Madre, Texas | September 1979 | 1 |
| Key West, Florida | May, August, November 1981; March 1982 | 4 |
| Houma, Louisiana | April, July, October 1981; January 1982 | 4 |
| Port Royal Sound to Savannah River, South Carolina | February 1982 | |
| Pensacola Bay & Chactowotcha Bay, Florida | April 1982 | |

2. Biodynamics of herds of bottlenose dolphins (marking, behavior, monitoring)

| | |
|---|---|
| Indian-Banana River (Asper/Odell) | 1980 |

(continued)

| Location | Dates of Surveys | Number of Surveys |
|---|---|---|
| 2. (continued) | | |
| Mississippi Sound | Planned | |
| Tampa Bay to Charlotte Harbor, Florida (Wells, Irvin, and Scott) | 1970-1972, 1974-76, 1980-present | |
| 3. Marine Mammal/Sea Turtles Stranding Network (Odell) | Continuous | |
| Bureau of Land Management | | |
| 1. Gulf of Mexico and South Atlantic Endangered Species Study (Fritts) | 1980-1981 | |

# BEHAVIORAL AND ECOLOGICAL STUDIES OF CETACEANS IN THE GULF OF MEXICO, SUMMARY REPORT

Louis M. Herman, Working Group Chairman
Kewalo Basin Marine Mammal Laboratory
1129 Ala Moana
Honolulu, HI 96814

and

Bernd Wursig, Co-chairman
Moss Landing Marine Laboratory
Moss Landing, CA 95039

## OBJECTIVES

The following summary considers separately each of the workshop objectives.

### 1. Ways in Which Cetaceans Might Be Affected by Offshore Oil and Gas Development

Oil and gas development may impact directly on populations of cetaceans through inducing behavioral change or indirectly through affecting habitat quality.

Platform construction along with increased maritime and helicopter traffic can produce considerable noise. An existing platform can continue to produce noise and additionally may release contaminants into the water.

These results of platform development or existence may interrupt long-standing migratory patterns of the open-ocean forms of Tursiops truncatus and other species, or lead to relocation of a school away from an area of habitual usage. In the short term, there may be local displacements of schools associated with transitory activities of the platform, such as helicopter arrivals, drilling, or the like.

The cohesiveness of the open-ocean school is likely greater than in the coastal forms, and displacements of individuals from the school can be serious to the individual. Foraging, feeding, and defense are all important functions served by the school and difficult for separated individuals. Hence it is important to study cohesion-fluidity variables of existing and planned platforms and their effects on the social structure of dolphinid schools.

Activities associated with platforms may in the short term induce or increase stress on individuals, which over time may increase the susceptibility of the individuals to disease, infection, parasites, etc., or may alter hormone levels and affect reproductive fitness.

The effects on individuals will likely be a function of the age, sex, and reproductive state of that individual. Probably the most vulnerable segment of the population with respect to disturbance is the calf. In captive situations at least, high mortaility has been observed in calves during the first several weeks or months after birth. Calf mortality has been associated with stress that is induced, for example, by lowering the water in a tank. Pregnant females may also be vulnerable. Captive situations show that pregnant females may in some cases abort under stress. Less vulnerable animals would proably be bachelor groups and large mature males.

Probably the indirect effect of greatest concern is the potential for disruption of the food web. If contaminants cause die-offs or lead to abandonment of an area by prey species of fish, schools of Tursiops can be expected to depart that area as well. Also, if hydrocarbons, heavy metals, etc., enter the food chain in an area of platform development, they could adversely affect the health and reproductive fitness of resident Tursiops schools providing the area was not abandoned by the school. Hence, it would be important to determine prior to development of new platforms in areas occupied by T. truncatus if that area is an important feeding ground, a resting area, nursery area, or perhaps only used in transit.

On the other hand, it may be that if a platform acts as an artificial reef, it contributes to the development of an area as a food resource. In such cases we may in fact find Tursiops attracted to platforms. Whether or not Tursiops will attempt to feed near platforms in the face of possible dispersive forces such as noise, vessels, aircraft, etc., remains a problem for study.

## 2. Types and Specificity of Data Needed to Predict, Detect, and Mitigate Possible Adverse Effects

Two experimental designs are proposed to examine changes in the distribution and behavior of cetaceans in response to offshore oil and natural gas development. The first of these is a natural experiment involving the comparison of behavior in areas differing in degrees of existing or planned development, and the second involves intervention studies in undeveloped areas.

In the natural experiment, the distribution and behavior of an appropriate cetacean species, probably T. truncatus in most areas, would be compared across areas already developed, adjacent areas not affected by development but slated for development, and in nearby "pristine" areas not slated for development. This experiment would allow for the immediate comparison of information between affected and non-affected animals, as well as provide for a natural experimental situation for monitoring non-affected areas as they become developed.

Intervention studies would facilitate the identification of the factors associated with development that may result in observed differences in behavior or distribution, if any differences exist. Controlled observations of behavior during periods of playback of industrial noise, aircraft or helicopter overflights, ship passage, or seismic airgun detonations have been used successfully in other areas (e.g., with bowhead whales in the Beaufort Sea and humpback whales in Alaskan waters). In some cases the petroleum industry has cooperated in providing vessels and aircraft for such experiments; this possibility should be explored for the Gulf of Mexico.

The kinds of information to be collected in these two experimental situations are similar. An assessment of whether or not animals may be leaving, entering, or otherwise changing their ranges in apparent response to development or the products of development must be made. Baseline information on respiration and surfacing characteristics are needed. Such behaviors appear to be good indicators of local stress in species. The frequencies of such behaviors as contact between animals, ventral-up postures, copulatory and pre-copulatory activities, fluke-out dives, tail slaps, and leaps should be compared between experimental and control situations. Synchrony of surfacing both between and within groups and subgroups should be examined. Group size, both in terms of numbers of individuals and dimensions of the group, should be studied. The numbers and positions of calves and other age and/or sex classes within the groups are important variables for consideration. Differences in behavior between age and sex classes, orientations, and vocal activity should be studied as well. All of these data should be collected on a systematic basis, and possible variation due to seasonal or diurnal patterns should be considered.

In addition to these experiments, laboratory and field data are needed to assess reactions and responses to oil. Attention in laboratory studies should be given to responses of the most vulnerable segments of the population, e.g., calves and mothers. Field experiments can use simulation techniques to gauge response to oil slicks. Non-toxic substances can be used as oil substitutes to test whether avoidance occurs. Laboratory and field experiments should coordinate their activities and goals to maximize information return.

## 3. Methods To Be Used To Obtain Needed Data

The workshop identified seven major avenues of research to be considered in order to gather data on the potential effects of oil and gas development on whales and dolphins.

(A). Aerial observations carried out by trained behavioral observers will help to answer questions about behavior patterns of animals unaffected by oil development, and potential behavior differences in developed areas. It was stated that such aerial behavior observations might be done in conjunction with existing surveys for distribution and abundance information. However, because the primary purpose of survey flying does not allow for prolonged flying over a particular group of animals to assess behavior in detail, a separate effort is much more desirable. It would also be desirable to have personnel who are intimately familiar with the

behavior of the target species of marine mammals and who can therefore describe and interpret behavioral interactions as consistantly as possible in the field.

Several techniques to aid in observation were suggested. Two behaviorists, in a twin-engine high wing aircraft, describe an animal or group of animals into cassette recorders while the airplane circles above. This focal group approach shall be augmented with a hand-held video camera to record behavior which can then be analyzed in greater detail in the laboratory by using microprocessor-assisted techniques. This also allows for gathering information on the surfacings of all animals of a group, group and subgroup synchrony, distances apart, etc. For a further refined analysis of group and subgroup structure, especially of dolphins, the use of a 35-mm motor drive still camera for sequential high resolution photographs was recommended. Both of these action-recording techniques have been highly successful in other behavioral studies of whales and dolphins from the air. Acoustic monitoring from the air via sonobuoys of marine mammal sounds and industrial sound was recommended. In addition to an assessment of marine mammal sound behavior relative to potential disturbance, it may often be possible to identify potential disturbance simply by listening to the kinds and levels of industrial sounds present in particular areas.

(B). Boat observations similar to the aerial observations listed can also be performed from either a dedicated vessel or vessels of opportunity. Potential disadvantages of this approach include low observation angle, slow movement of the boat between groups of dolphins or whales, possible disturbance, and, in the case of a dedicated vessel, high cost. Advantages include the potential for a longer time series of observations than is possible from aircraft.

(C). Tagging for individual identification and the use of natural marks through photographic study were also discussed. These techniques have been used successfully for studies of coastal Tursiops. Radio tracking by conventional receivers as well as by satellite was mentioned. Radio tagging would provide information within a relatively short study period on home ranges and surfacing characteristics, on dive times and optionally on depths of dives. Radio transmitters attached to the dorsal fins of bottlenose dolphins might also be equipped with sensors for heart rate, so that one indicator of stress could be monitored. Radio transmitters for large whales were also mentioned, and the recommendation was made to study the feasibility of attaching a radio tag to a sperm whale in order to begin to understand sperm whale movements and dive patterns within the gulf.

(D). Laboratory and field experiments that systematically introduce simulated conditions of development activities to marine mammals must be considered. In the laboratory, such work has already progressed, especially with the study of dolphin reactions to oil. Sounds of drilling, seismic operations, vessels, etc., may also be introduced. But the best chances of assessing behavior properly would rely on experiments in nature. Recordings played back through a Navy J-11 speaker at close range may simulate industrial noise, and, vessels that operate in an area may be diverted to assess the animals', short- and longer-term reactions

before, during, and after such potential disturbance. Such assessment would be best done by observing from a circling aircraft as described above.

(E). Continuation and elaboration of the stranding network were suggested to learn about cetacean distribution and food habits. Biopsy tissues may be obtained in some cases for stress analysis. There are some difficulties with such data because animals present in an area may strand less than in other areas for topographic or other reasons. The stranding network, however, costs relatively little to maintain and is cost effective. Similar data may be gathered from animals killed incidental to fish-netting operations as well. Since such animals were presumably more healthy than stranded individuals, data on them may be more representative of the population as a whole.

(F). Feeding biology studies in which prey of especially T. truncatus are identified should be implemented, and the potential effects of development on the prey and therefore on the dolphins should be assessed. Stomach contents of dolphins could be obtained from stranded and incidentally killed animals, or from healthy animals by using a lavage technique. Identification of prey would be followed by an integration of available knowledge of development on these prey species, or experimental work as necessary.

(G). Sighting forms should be developed for distribution to ships and aircraft to record opportunistic observations of cetaceans. These forms should include time and location data, species (a guide to species is needed), and a simple behavioral checklist to include movement directions and speed of movement, estimate of number of animals, and estimate of maximum breadth/depth of school.

## 4. Priorities

It was generally decided that the most important animal for study is T. truncatus. It is ubiquitous both within channels and bays in developed and undeveloped areas offshore. It has likely been affected to date by oil development, and such impact may be measured by behavioral monitoring of the three chosen areas as discussed in item #2 above. As more becomes known about the distribution of Stenella spp. in the chosen survey and experimental areas, observation of one of these species may be desirable as well. Large whales must be studied on an opportunistic basis as they enter these areas.

Several priorities were identified:

(1) Researchers who have done behavioral studies on T. truncatus in Gulf of Mexico waters and elsewhere should pool their information and compare and contrast the behavior and ecology of populations in different parts of the gulf.

(2) Aerial surveys to assess relative presence and abundance of marine mammals should commence in designated areas.

(3) A behavioral study from the air, as outlined above, to learn more about the behavior and movement patterns of especially T. truncatus in the areas of interest should begin.

(4) Some radio tracking of individual T. truncatus in the study areas to assess home range sizes and movement patterns as well as diurnal and seasonal changes should be initiated. This kind of study has been valuable to researchers studying inshore T. truncatus in the Sarasota-Bradenton area of west Florida. It would be especially profitable to initiate research of the offshore animals adjacent to this well-studied Sarasota population to augment ongoing studies of naturally marked individuals, for an assessment of similarities and differences between onshore and offshore animals, and to determine the degree of interchange that may occur between the groups.

(5) Monitoring and analysis of strandings should be supported.

It was stressed that experienced whale behaviorists should be chosen to do the behavioral work outlined. The level of study effort should be at least 3 years so that yearly variations in movement patterns or other variables can be identified. Better cooperation in combined research between government agencies as well as universities should be strived for, although the difficulties of such cooperation were recognized. The fishermen of the coastal zone represent a vast, relatively untapped source of knowledge, and it was suggested that efforts be made to gather and collate information from this important source. Above all, the need for hard quantitative data on Gulf of Mexico marine mammals was recognized. We believe that the behavioral program outlined above, to concentrate mainly on T. truncatus, will make a significant contribution in providing such quantitative data.

In summary, the program concentrates on an area already affected by development, one not affected but slated for development, and one which may be used to monitor relatively undisturbed animals for a longer time. This is to be accomplished mainly by survey and behavioral overflights and possibly behavioral investigations from boats. Such information is to be augmented by continued analyses of strandings and by a coordinated effort of different factions to pool their data.

# PHYSIOLOGICAL STUDIES OF CETACEANS IN THE GULF OF MEXICO

SUMMARY REPORT

David J. St. Aubin, Working Group Chairman
Department of Pathology
Ontario Veterinary College
University of Guelph
N1GZW1, Canada

and

Moby Solangi, Working Group Co-chairman
Marine Life Inc.
150 Debuys Rd.
Biloxi, MS 39531

## INTRODUCTION

The physiological effects of oil and oil-related activities on cetaceans are a subject of great concern. There are only a few reliable field reports of cetaceans in the vicinity of oil spills, and none identify any physical or physiological impact. Recently a study funded by the Bureau of Land Management (BLM) has been undertaken at the University of Guelph, Ontario, to investigate some of the possible consequences of oil exposure on these animals. There is still a need for additional work to focus on the cetaceans of the Gulf of Mexico and the features of their environment that could influence the impact of exposure to oil and oil-related activities.

Geraci and St. Aubin (1980) reviewed the possible effects of offshore petroleum resource development on cetaceans. These concerns were reiterated in our workshop discussion session to help identify research needs for the gulf region. A set of priorities emerged from those discussions, along with recommendations for research. An integrated study plan was developed to maximize data collection and to take advantage of programs that are presently in operation or that were recommended in the other workshop sessions.

## SHOCK WAVES

Shock waves from the detonation of explosives under water can cause fatal damage to organisms. Seismic surveys and construction and removal of drilling structures may necessitate the use of explosives, and thereby pose a threat to cetaceans within critical range. Formulas have been developed to calculate

safe distances, taking into account body size, depth of water and charge, and size of charge (Yelverton et al. 1973). Cetaceans may be somewhat less vulnerable than the terrestrial species for which these formulas were developed because of their larger size, thick body walls, and anatomical and physiological adaptations which allow them to withstand pressure.

Further studies aimed at defining the thresholds for damage caused by shock wave overpressures do not appear to be necessary. When explosives must be detonated under water, efforts should be made to ascertain whether any cetaceans are within critical range, and to modify the charge or detonate a small "scaring" charge if the animals are considered to be dangerously close. If possible, observations should be made on the behavioral response of animals in the vicinity of such explosions, and any casualties should be identified and examined.

## NOISE

Noise is associated with all phases of offshore petroleum exploration and production. High intensity sound, such as might be associated with seismic surveys, can overstimulate sensitive auditory receptors, resulting in damage to sensory cells and impaired hearing. Such changes are morphologically detectable, but functional correlations are difficult to establish. Impulse noise often elicits a startle reflex, and can lead to stress-mediated hormonal imbalances which have profound physiological consequences. Cetaceans generally respond to sudden disturbances by sounding, aggregating, or dispersing. In addition to the stress of disrupted social structure, such responses to unusual disturbances have been circumstantially linked to stranding.

Chronic "background" noise from drilling platforms and ship traffic may also constitute a stress for cetaceans by masking intra-specific communication or interfering with acoustic detection of prey. Most of the sound energy produced by oil-related activities is low frequency and therefore should not affect high frequency echolocation by odontocetes. Mysticetes, however, may use ambient sounds for spatial orientation and/or detection of prey (Watkins and Schevill 1976), and these may be more difficult to detect when background noise levels are high.

Some cetaceans have habituated to human activities, such as the "whale-watching" cruises on the Pacific and New England coasts, and undoubtedly they have accommodated somewhat to the considerable oil exploitation activity which has long been in effect in the Gulf of Mexico. Yet we do not know how stressful this accommodation has been. The hormonal responses to short- and long-term stress have not been extensively studied in dolphins, but adrenal overstimulation in other mammals typically is associated with immune-suppression and possible interference with reproductive cycles.

Continued efforts should therefore be made to monitor the health status of cetacean populations in the Gulf of Mexico. Through the study of stranded animals, particularly small herds of dolphins, considerable information can be obtained on condition, incidence of disease, reproductive activity, and pollutants in tissues. In the Northeast, such studies have provided some insight into the role of stress and disease as factors that may affect reproductive success and contribute to cetacean mortality. For example, a high incidence

of adrenal lesions in mature female white-sided dolphins, Lagenorhynchus acutus, was possibly correlated with burdens of parasites, including a nematode which destroys functional tissue in mammary glands (Geraci and St. Aubin 1979; Geraci et al. 1978).

While causal relationships between numerous environmental factors and strandings are tentative at best, a salvage and necropsy program in some cases is the only source of information about certain species. It is recommended that the existing stranding network in the gulf region be supported in monitoring the health status of resident and transient cetacean populations.

## OIL EFFECTS

Cetaceans directly exposed to an oil spill risk contact with potentially harmful petroleum by inhalation, ingestion or skin contact. Studies at the University of Guelph, Ontario, have focused on structual and functional effects of crude oil and gasoline on cetacean skin. The consequences of oil ingestion and inhalation have not been addressed in cetaceans, but have been reported extensively for other species. Indirect effects are more difficult to identify and study, but may include subtle organ damage, and reproductive disturbance associated with petroleum hydrocarbon levels in tissues. In the final analysis, the acute and chronic effects of oil will be strongly influenced by such environmental and biological factors as levels of other pollutants, disease, and stress.

### Surface Contact

The skin of cetaceans is morphologically and biochemically unique and may be adversely affected by petroleum hydrocarbons. Recent studies have identified specific ultrastructural and metabolic defects in bottlenose dolphin skin following exposure to oil and gasoline. The consequences and scope of these changes are the focus of a continuing research program, though it does not appear that such exposure would present a major threat to an otherwise healthy dolphin.

Environmental conditions in certain areas of the gulf region might affect the reaction of cetacean skin to oil. During the spring and early summer, salinity in Mississippi Sound and adjacent waters drops dramatically. In captivity, freshwater immersion for more than 1 to 2 days causes skin sloughing in dolphins (E. Asper, Sea World, Orlando, Florida; pers. comm.), suggesting that the integrity of intercellular bridges has been disrupted. Similar but perhaps more subtle changes may occur in dolphins inhabiting estuarine environments in the gulf, and could affect the reaction of their skin to oil.

Studies are needed to determine the dynamics of dolphin skin structure and function under varied environmental conditions, with a view towards identifying characteristics of the skin that might make it sensitive to oil. Much can be learned from skin biopsy samples from dolphins captured as part of the effort to obtain exhibit animals. Generally, many dolphins are handled before the desired individuals are captured, thereby making available a cross section of age groups during different seasons and from different waters. Studies on

captive animals will further contribute to our basic understanding of cetacean skin, and provide the opportunity for controlled experiments on oil exposure.

## Oil Ingestion

The effects of ingested oil depend upon the amount consumed, the composition or nature of the oil, and whether or not the ingested oil is regurgitated and aspirated. Based on LD50 data for other species, it is unlikely that medium to large-sized cetaceans could consume enough oil to experience toxic effects. Furthermore, their peculiar laryngeal anatomy precludes the possibility that any ingested oil could be aspirated into their lungs. Oil ingestion may pose more of a threat to smaller species and particularly to calves.

Cetaceans might be affected by long-term ingestion of food contaminated with petroleum residues. Such compounds, along with numerous other chemical and heavy metal contaminants, are discharged continuously by the Mississippi River and undoubtedly contaminate many of the food species. The subtle effects of bioaccumulation of these substances have not been clearly established, but there is some indication that organochlorines (PCB, DDT) cause reproductive failure in seals and sea lions.

Studies on stranded cetaceans along the New England coast have shown that naphthalene, one of the petroleum fractions transferred from fish to marine mammals, can accumulate in blubber. The concentrations detected are not cause for immediate concern. However, mobilization of fat stores during lactation or migration could lead to the release of these and other lipophilic residues, thereby accentuating the toxic effects.

A surveillance program, such as the existing gulf region stranding/necropsy network, should be supported to gather data on tissue levels of petroleum hydrocarbons, organochlorines, and heavy metals in cetacean tissues. Such data can be augmented by analyses of biopsy samples from live-capture operations in an attempt to determine if increased levels of these substances are associated with functional disturbances.

## Inhalation

Cetaceans in the midst of an oil spill will likely inhale petroleum vapors, which in some instances may be mixed with hydrogen sulfide gas. High concentrations of volatile hydrocarbons are rapidly fatal. Sublethal effects principally include neurologic disturbances and irritation to mucous membranes of the eyes and respiratory system. Hydrocarbons absorbed through the respiratory mucosa have further systemic effects on the kidneys, liver, adrenals, stomach, and the hematopoietic system (bone marrow).

Under most circumstances, vapor concentrations above an oil spill would not likely reach critical levels for a long enough time to present a serious threat. Nevertheless, specific data are lacking. Special attention should be paid to levels of hydrogen sulfide, which even in low concentrations could dramatically alter the susceptibility of individuals to hydrocarbon vapors. The risk may be further increased because of the warm air and water temperatures in the gulf, which would accelerate the evaporation of harmful substances.

Pre-existing lung disease associated with parasites is another factor that could influence a cetacean's vulnerability to hydrocarbon vapors. A stranding/necropsy program can provide data on the incidence and intensity of parasitic infection, lung disease, and general condition of cetaceans in the gulf, which would be useful in predicting the possible effects of hydrocarbon vapor inhalation. Studies of toxic thresholds in cetaceans are unnecessary in view of the abundant literature for other species.

### Miscellaneous Effects

Dissolved hydrocarbons from oil spills or river runoff may have a subtle effect on cetacean reproductive behavior. Observations in captivity suggest that pheromone-like substances may serve as cues for mating behavior, though the mechanisms involved are unknown. A sense of taste has recently been demonstrated in dolphins, but it is the only chemoreceptive sense described for these animals. Nevertheless, pollutants in the water column might interfere with detection of sexual cues. Considerable basic research would be required to identify the active substances, determine how they are detected, and establish if dissolved hydrocarbons interfere with the detection mechanism.

## RECOMMENDATIONS

The working group supported three basic approaches to gather a wide variety of data on the physiological effects of oil on cetaceans: a stranding/necropsy program, sampling of live-caught Tursiops truncatus, and a contingency oil spill investigation plan.

Stranded animals have proved to be a source of considerable information on life history, disease, and stress. Such data are needed to help establish the status and fitness of the various cetacean species in the gulf. Baseline data are needed to assess bioaccumulation of pollutants for comparison with levels in other populations and for interpretation of analyses performed on cetaceans recovered near an oil spill.

The capture of live Tursiops for display or research (e.g., tagging studies) offers a unique opportunity to gather samples and data from a cross section of the population. Biopsies of blubber should be tested for pollutant residues, skin samples examined for morphological and biochemical disturbances, and blood samples analyzed for enzymes, steroids, and other constituents that are sensitive indicators of stress and disease.

In the event of an oil spill, efforts should be made to gather as much behavioral, physiological, and toxicological data as possible through observations of cetaceans exposed to the oil and detailed study of dead or moribund animals found in the vicinity. A team of qualified researchers should be identified from the gulf region, and their level of input and area of expertise should be defined prior to such an event, to expedite the mobilization of the team following a spill. To assess physiological and pathological effects, blood and tissue samples must be tested for evidence of oil-induced toxicity. For example, specific enzymes released from damaged tissues can be detected in the blood, and serve to pinpoint the site and extent of damage. Pathological studies should focus on skin, and correlate field observations with data that

are now available from controlled laboratory studies. Concentrations of hydrocarbon and hydrogen sulfide vapors should be measured to help assess the risk of inhalation effects.

The expertise and facilities to carry out these programs are already in existence in the gulf region. A stranding/necropsy program has been functioning for a number of years, but needs further support to extend its coverage and the completeness of the data. Tissue analyses have not been performed as yet because of the relatively high cost. Efforts should be made by the various agencies to develop joint programs to maximize the collection of data, particularly from the live-capture effort in the gulf. Information on distribution, behavior, physiology, and condition can all be gained, but not without additional cost. The logistics and expense of such a joint program should be thoroughly investigated.

## REFERENCES


Geraci, J.R., and D.J. St. Aubin. 1979. Stress and disease in the marine environment. Pages 223-233 in Biology of marine mammals: insights through strandings. NTIS Report No. PB-293 890.

Geraci, J.R., and D.J. St. Aubin. 1980. Offshore petroleum resource development and marine mammals: a review and research recommendations. Mar. Fish. Rev. 42(11): 1-12.

Geraci, J.R., M.D. Dailey, and D.J. St. Aubin. 1978. Parasitic mastitis in the Atlantic white-sided dolphin, Lagenorhynchus acutus, as a probable factor in herd productivity. J. Fish. Res. Board Can. 35: 1350-1355.

Watkins, W.A., and W.E. Schevill. 1976. Right whale feeding and baleen rattle. J. Mammal. 57 (1): 58-66.

Yelverton, J.T., D.R. Richmond, E.R. Fletcher, and R.K. Jones. 1973. Safe distances from underwater explosions for mammals and birds. Lovelace Foundation for Medical and Education Research, Albuquerque, N.M. 63 pp.

SEA TURTLE WORKING GROUP RESULTS

# OIL AND SEA TURTLES IN THE GULF OF MEXICO: A PROPOSAL TO STUDY THE PROBLEM

Dave Owens, Working Group Chairman
Biology Department
Texas A&M University
College Station, TX 77843

## INTRODUCTION

Continued development and utilization of Federal waters on the Outer Continental Shelf (OCS) for oil and gas production are a critical national priority. With 2,437 platforms and 17,407 wells in place in Federal waters, we now obtain nearly 15% of our domestic crude oil and one-third of our gas from the Gulf of Mexico (Gallaway 1981). Considering the aims of the United States in the gulf and the increasing utilization of the resources by Mexico, we are long overdue in evaluating and attempting to minimize the biological impacts of OCS development on the sea turtles of the region.

Marine turtles are an ancient group of animals. Not only do they predate man and mammals, they were swimming the seas even before there were dinosaurs or a Gulf of Mexico. Historians tell us that the red meat protein of sea turtles was a crucial factor in facilitating the early exploration of the Americas. By the year 1900 most of the easily accessible nesting colonies of green turtles (Chelonia mydas) in Florida, Cuba, and the Caymans had been destroyed. The last turtle cannery in Texas closed around the turn of the century, while the factories in south Florida persisted into the 1970's. Turtles are still an important fishery resource in Mexico and much of the tropical Third World.

## THE STUDY OF SEA TURTLES

There are certain disadvantages and advantages in working with sea turtles when studing the effects of oil on animals. We are disadvantaged because the time in the life cycle when maximal impacts of oil might be expected is the neonatal or hatchling period which we know the least about. We simply do not know where neonatal sea turtles live. In fact, Dr. Archie Carr, using the critically endangered Kemp's ridley of the Gulf of Mexico as his example, believes that understanding the early life history of sea turtles is the most important unsolved problem in sea turtle biology (Carr 1980). The term "lost year" has been used for this stage, even though the turtles are not "lost" and the stage certainly may last longer than a year.

The second disadvantage actually encompasses the first in that we know little about sea turtle biology in general. Nesting is well studied, but once the turtle enters the sea, scientists encounter several blanks in terms of distribution, physiology, and behavior. In short, all of the information needed to evaluate the impacts of oil on these species remains enigmatic. It is quite embarrassing to the average sea turtle biologist when he cannot tell students touring the lab the sex of a 200-lb turtle. In a way, our natural mammalian bias has actually thrown us off the track. For example, we just recently found out that sea turtles do not have an XY chromosome sex determination system. Rather, the temperature at which the eggs incubate on the beach determines what sex the embryo will become (Mrosovsky 1980). Sex ratios can in fact be quite skewed: loggerhead turtles (Caretta caretta) will be all males if the beach is 28°C or less and all females if 30°C or greater. These problems and many others are making population models difficult to produce.

On the more positive side, there are also advantages for the scientist in evaluating potential oil impacts on sea turtles. Neonatal and embryonic sea turtles make excellent experimental animals when brought into the laboratory. By obtaining them as eggs or before they enter the sea, one can easily rear them in captivity since they will eat almost anything and do not need the water quality required for fish. The only exception is the leatherback (Dermochelys), which is quite difficult to maintain in captivity.

A second advantage is that turtles lend themselves to physiological studies because it is quite easy to take repeated blood samples, stomach contents, or muscle and skin biopsies. You do not have to kill these endangered species to work with them. They are indeed hardy animals compared to many other vertebrates.

A final advantage is that one can obtain large individuals by conventional techniques. In a National Marine Fisheries Survey of the Cape Canaveral Channel, one 15-minute trawl from a shrimp boat produced 16 turtles ranging in size from 20-inch immatures to huge adult males over 300 lb. Other netting and trapping techniques also work well. Thus, samples can be obtained and experiments conducted on wild sea turtles after the "lost year" stage.

## KNOWN EFFECTS OF OIL

The best documented effect of oil on turtles is the fatalities that occur when neonates encounter fresh oil or tar (Witham 1978). Young turtles fouled with oil or tar have died even with individual rehabilitation and care. Neonatal turtles are most likely transported by surface currents and may end up in driftlines and gyres. Since surface oil is transported in a simliar fashion, neonates may frequently encounter oil. There is a reasonable chance that the entire natural hatch of Kemp's ridley (Lepidochelys kempi) for 1979 may have eventually become involved in the Ixtoc I oil spill. The nearshore waters of the only nesting beach for the species are located in direct line with the path of the spill as it moved into Texas. Although the neonates were air lifted off the impacted beach to non-oiled areas a few miles offshore, there is a likelihood that they contacted surface oil later.

A second potential impact, which has not occurred to our knowledge, would be the direct inundation of a nesting area during the mating season. Both

adult females and males would most certainly be fouled in the water during mating, and the adult females would be fouled on the beach during nesting. These adults would probably be able to recover from such an inundation or avoid the area altogether. The embryos, on the other hand, would experience increased mortality and morphological malformation from contact with oil (Fritts and McGehee 1981). Clearly the Ixtoc spill narrowly missed having such an impact on the nesting beach just 150 mi south of Brownsville, Texas. A year later during the 1980 nesting season, the oil had weathered sufficiently so that impacts were not suspected.

## POSSIBLE EFFECTS OF OIL

Three possible effects which are not documented include more subtle behavioral or physiological impacts of oil or oil industry byproducts. In particular, since all sea turtles are carnivorous to some degree, they could potentially bioaccumulate foreign chemicals such as heavy metals which occur in drilling muds. This problem may be magnified because turtles appear to be attracted to offshore platforms, as divers commonly note. Such impacts could ultimately reduce reproductive fitness in sea turtles, an effect the already-reduced population cannot handle.

The second point of concern is a potential behavioral attraction that the tar balls or soluble oil fractions might have, particularly to neonatal turtles. Kleerekoper and Bennett (1976) found that one of seven green turtle hatchlings monitored in a large tank was attracted to the water soluble fraction of Louisiana crude oil. All of the turtles appeared to demonstrate modified behavior after exposure to the oil products. These preliminary studies indicate a need for further experimentation.

A third potential impact involves brightly lit drilling structures since sea turtles use light (the brighter horizon) to cue escape from the nest or beach to the sea. If neonates were attracted to the brightly lit drilling structures, where large birds and fish also congregate, predation would increase dramatically.

## PROPOSED RESEARCH PROGRAM

After deliberating over many plans that attempt to fill all the missing gaps about sea turtle biology, the workshop group confined their recommendations to studies that directly address the impact of OCS development on turtles and turtle populations. The following studies have been recommended by workshop participants:

### 1. Impact of Oil on Neonatal and Juvenile Sea Turtles and Their Habitats

Rationale: Fatalities of young sea turtles fouled with oil and tar have already been observed. The magnitude of this problem for sea turtle populations is still undetermined. The most commonly accepted hypothesis concerning neonatal distribution suggests an association with pelagic drift lines which contain Sargassum or flotsam, for example. This is where floating oil and tar would also accumulate.

Task A. Identify neonatal turtle habitat and determine the extent of oil present.

(1) By examining drift lines, particularly in areas where turtles hatch and probably drift along, determine presence and abundance of oil and oil by-products.

(2) Using boats, trace the drift paths of neonatal turtles as predicted from current models. Night attraction lights off boats and platforms of opportunity as well as dyes and tags could be used to track animals. Of special concern would be L. kempi, which, based on current patterns, would be predicted to cross the OCS of Texas shortly after hatching.

Task B. Determine the effects of crude oil and tar balls on neonate and juvenile (first year) turtles.

(1) In laboratory experiments, determine the feeding preferences and avoidance/attraction interactions with oil products.

(2) In laboratory experiments, determine the physiological effects of ingestion and contact with oil products.

Task C. Use the existing sea turtle stranding network to evaluate oil-turtle interactions, in terms of both mechanical and physiological impacts.

2. The Effect of Crude Oil Spills Contacting Sea Turtle Nesting Beaches

Rationale: Crude oil has been shown to cause increased mortality and morphological anomalies in sea turtle embryos. For proper impact assessment, the details of the toxic and sublethal effects of crude oil during this most vulnerable period in the turtle's life history need to be addressed.

Task A. A research program should be developed to address the effects of crude oil on sea turtle eggs, embryos, hatchlings and nesting females. This program would be aimed toward impact assessment and recommendations for the mitigation of potential impacts.

3. The Feeding Biology, Population Structure, and Seasonality of Turtles off Western Florida

Rationale: Recent aerial studies by Fritts et al. (1982) indicated large populations of sea turtles off western Florida where oil and gas production and exploration are beginning. The significance of this area to sea turtle populations needs to be determined in order to address impacts of offshore development.

Task A. Determine the population structure (size classes) of these populations.

(1) Use aerial surveys including photographic techniques to determine size classes, species composition, and seasonal distribution of the population.

(2) Use surface vessels and netting techniques to generate actual "ground truth" measurements of turtle size, stomach contents, diurnal activity, diving

frequency, and physiological condition (sex, health, oil byproduct contamination). Radio tracking, satellite location, and blood sampling are a few of the techniques that would be used.

Task B. Use the existing sea turtle stranding network to study the population ecology and interaction of turtles with oil.

4. Habitat Use and Effects of Oil on Sea Turtles (especially L. kempi) in Louisiana and East Texas Waters

Rationale: Historically, the Mississippi Delta region has been considered as a primary juvenile and adult feeding ground for L. kempi. However, because of low densities, secretive behavioral patterns, or water turbidity, few turtles were observed from the air in a recent survey (Fritts et al. 1982). It was thought that an intensive search for these animals using methods other than aerial observation was needed to determine the effect of extensive offshore development on this population in Louisiana.

Task A. Determine where and when L. kempi, C. caretta, and D. coriacae occur in relation to existing oil platforms and shipping lanes.

(1) Initial techniques to be used will be surveys of fishermen, oil rig workers, and pilots, as well as platform-of-opportunity searches on board ships, aircraft, and oil rigs in the area.

(2) Intensive boat-based search and radio tracking of individuals should be conducted, based on the results of (1) above. Quantification of existing oil and turtle interactions would be the primary research product.

Task B. Use the existing sea turtle stranding network to quantify interaction of oil products and oil platforms with sea turtles.

5. Data Synthesis for Management Recommendations

Rationale: A separate unit is needed to ensure a final synthesis of the data generated in studies of the interaction between OCS development and sea turtles. This synthesis will be directed toward conflict resolution.

Task A. Produce management models for each of the impacted species of sea turtles with specific recommendations on methods to reduce and minimize the negative interaction between turtles and the offshore oil and gas development.

## CONCLUSION

Funding for work on endangered species and particularly sea turtles has been limited. The recent MMS-supported aerial survey conducted by Fritts et al. (1982) has made an important contribution to understanding the distribution and abundance of turtles in the gulf coast region. By carefully researching the situation in the designated critical impact areas, the MMS will be able to initiate a rational plan designed to ensure the survival of these important species. We believe the research approach proposed herein will provide the necessary data needed to make decisions that balance the interests of the United States, the oil industry, and the turtles.

It is of critical importance that interested scientists and citizens voice their concerns and become involved in recovery attempts. It would be unthinkable, considering our modern technological capabilities, to allow future oil and gas development to eliminate these species forever.

We would recommend establishment of an intergovernmental council composed of agency scientists from the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and the National Park Service. This group would be charged with the responsibility of coordinating government and private research efforts on behalf of the endangered sea turtle species.

In addition to coordination of U.S. efforts, we consider it of paramount importance to involve Mexican government agencies and scientists at all levels of future planning for this research program. The United States joined a pre-existing Mexican effort to save the Kemp's ridley in 1978. The Mexicans consider this species their special concern. Clearly, saving this species, as well as most other sea turtles, constitutes an international concern. Since Mexico has important populations of all the endangered sea turtles and heavily exploits each of the other species, success in the effort with Kemp's ridley constitutes a crucial test of the conservation ethic in Mexico. The United States must do everything possible to encourage this experiment in Mexico while taking special care not to jeopardize their efforts.

## REFERENCES


Carr, Archie. 1980. Some problems of sea turtle ecology. Am. Zool. 20:489-498.

Fritts, T., and M.A. McGehee. 1981. Effects of petroleum on the development and survival of marine turtle embryos. Joint meeting of Society for the Study of Amphibians and Reptiles and the Herpetologists' League. Memphis, Tenn. 44 pp. (Abstr.)

Fritts, T., B. Irvine, R. Jennings, L. Collum, W. Hoffman, and A. McGehee. 1982. Turtles, birds, and mammals in the northern Gulf of Mexico and nearby Atlantic waters. U.S. Fish and Wildlife Service, Office of Biological Services. (In prep.)

Gallaway, B.J. 1981. An ecosystem analysis of oil and gas development on the Texas-Louisiana Continental Shelf. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C. FWS/OBS-81/82. 89 pp.

Kleerekoper, H., and J. Bennett. 1976. Some effects of the water soluble fraction of Louisiana crude on the locomotor behavior of juvenile green turtle (Chelonia mydas) and sea catfish (Arias felis). Preliminary results. American Petroleum Institute.

Mrosovsky, N. 1980. Thermal biology of sea turtles. Am. Zool. 20:531-547.

Witham, R. 1978. Does a problem exist relative to small sea turtles and oil spills? Pages 62-63 in Proceedings of a conference on the assessment of ecological impacts of oil spills, 14-17 June 1978. American Institute of Biological Sciences, Keystone, Colo.

# LIST OF PARTICIPANTS

ADAMS, Ken
U.S. Fish and Wildlife Service
National Coastal Ecosystems Team
1010 Gause Blvd.
Slidell, LA 70458

ASPER, Ed
Sea World
7007 Seaworld Dr.
Orlando, FL 32809

AVENT, Bob
Minerals Management Service
P.O. Box 7944
Metairie, LA 70010

BENIGNO, Joseph
National Marine Fisheries Service
3209 Fredric St.
Pascagoula, MS 39567

BENTLY, Tim
University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149

BOERSMA, Dee
Institute for Environmental Studies
University of Washington
Seattle, WA 98195

BROWNELL, Robert
U.S. Fish and Wildlife Service
P.O. Box 67
San Simeon, CA 93452

Butler, Dick
National Marine Fisheries
3209 Fredric St.
Pascagoula, MS 39567

CALDWELL, David
University of Florida Marine Laboratory
Route 1, Box 121
St. Augustine, FL 32084

CALDWELL, Melba
University of Florida Marine Laboratory
Route 1, Box 121
St. Augustine, FL 32084

CAREW, Robert
MAR, Inc.
3104 Thomas Drive
Panama City, FL 32407

CASON, Otis
Tetra-Tech, Inc.
Pass Christian, MS

DUKES, Gerald
Handsboro Animal Hospital
01445 Pass Rd.
Gulfport, MS 39501

FORD, ROBERT S.
National Marine Fisheries Service
3209 Fredric St.
Pascagoula, MS 39567

FRITTS, Thomas
U.S. Fish and Wildlife Service
Museum of Southwestern Biology
University of New Mexico
Albuquerque, NM 87131

FULLER, Deborah
Louisiana State University
Baton Rouge, LA 70803

GALLAWAY, Benny
Ecological Research Associates, Inc.
1410 Cavitt St.
Bryan, TX 77801

GRACY, Bob
National Marine Fisheries Service
3209 Fredric St.
Pascagoula, MS 39567

GRUBER, Jody
c/o Holbuder
10403 Tennis Ct.
Houston, TX 77099

GUICE, Charlie
Minerals Management Service
P.O. Box 7944
Metairie, LA 70010

HERMAN, Lou
Kewalo Basin Marine Mammal Laboratory
1129 Ala Moana
Honolulu, HI 96817

HILDEBRAND, Henry
413 Millbrook
Corpus Christi, TX 78418

JACOBS, Judy
U.S. Fish and Wildlife Service
Jackson, MS

JOHNSTON, Jimmy
U.S. Fish and Wildlife Service
National Coastal Ecosystems Team
1010 Gause Blvd.
Slidell, LA 70458

KELLER, Cherry
U.S. Fish and Wildlife Service
National Coastal Ecosystems Team
1010 Gause Blvd.
Slidell, LA 70458

KNIGHT, Charles
Minerals Management Service
P.O. Box 7944
Metairie, LA 70010

LEHMAN, Jake
Minerals Management Service
P.O. Box 7944
Metairie, LA 70010

LEVENSON, Cole
NORDA Code 343
NSTL Station, MS 39529

LINDSTEDT, Dianne
Louisiana Geological Survey
P.O. Box G
Baton Rouge, LA 70893

LUND, Frank
118 Newins-Zeigler Hall
University of Florida
Gainesville, FL 32611

MAJOR, Peter
Marine Mammal Commission
1625 I. St., NW
Washington, DC 20006

MASSEY, Larry
National Marine Fisheries Service
75 Virginia Beach Dr.
Miami, FL 33149

McVEY, Jim
National Marine Fisheries Service
3500 Delwood Beach Rd.
Panama City, FL 32407

ODELL, Daniel
University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149

OWENS, Dave
Biology Department
Texas A&M
College Station, TX 77843

ROGERS, Robert
Minerals Management Service
P.O. Box 7944
Metairie, LA 70010

ROITHMAYR, Charles
National Marine Fisheries Service
3209 Fredric St.
Pascagoula, MS 39567

SCHMIDLY, Dave
Department of Wildlife &
Fisheries Science
Texas A&M University
College Station, TX 77843

SHANE, Susan
230 Miraflores Rd.
Scotts Valley, CA 95066

SHANKS, Larry
U.S. Fish and Wildlife Service
National Coastal Ecosystems Team
1010 Gause Blvd.
Slidell, LA 70458

SOLANGI, Moby
Marine Life Inc.
150 Debuys Rd.
Biloxi, MS 39531

ST. AUBIN, David
Department of Pathology
Ontario Veterinary College
University of Guelph
Guelph, Ontario
N1GZW1, Canada

STEWART, Bob
U.S. Fish and Wildlife Service
National Coastal Ecosystems Team
1010 Gause Blvd.
Slidell, LA 70458

THOMPSON, Nancy
National Marine Fisheries Service
75 Virginia Beach Drive
Miami, FL 33149

THOMPSON, Tom
Aero Marine Inc.
Groton, CT

WELLS, Randy
Dolphin Biology Research Associates
163 Siesta Dr.
Sarasota, FL 33581

WINN, Howard
Graduate School of Oceanography
University of Rhode Island
Kingston, RI 02881

WITHAM, Ross
Florida Department of Natural
Resources
P.O. Box 841
Jensen Beach, FL 33457

WURSIG, Bernd
MOSS Landing Marine Laboratory
Moss Landing, CA 95039


**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.