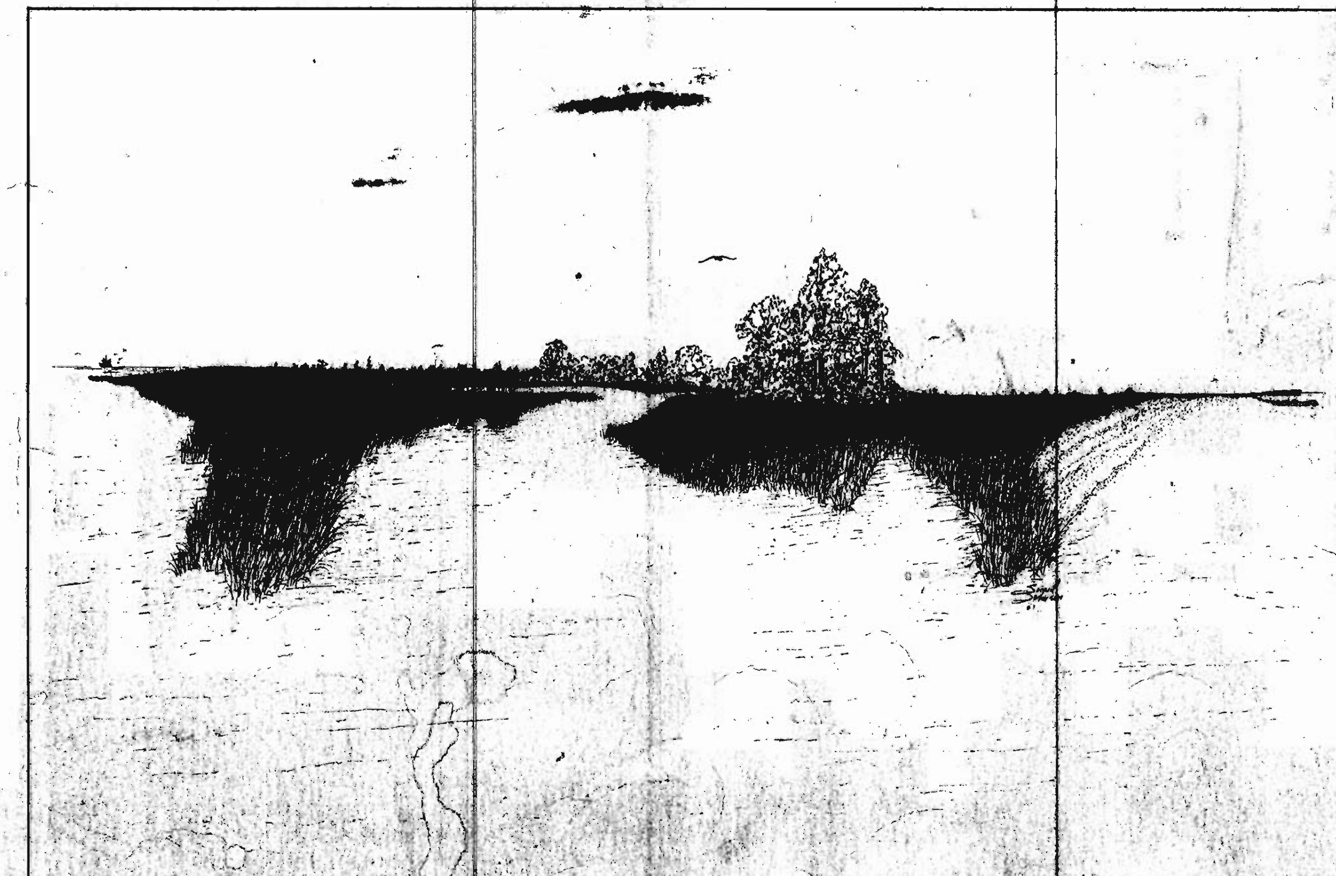
A Contingency Guide to the Protection of Mississippi Coastal Environments from Spilled Oil

Protection Priorities and Related Environmental Information

Mississippi Department of Wildlife Conservation
Bureau of Marine Resources
Long Beach, Mississippi 39560

April 1984



WILLIAM A. ALLAIN
Governor

MISSISSIPPI DEPARTMENT OF WILDLIFE CONSERVATION

Bureau of Marine Resources
P. O. Drawer 959
Long Beach, MS 39560
(601) 864-4602
Enforcement Division - 374-3205

Commissioners:

Jim Hunter McCaleb
Cleveland, MS

Lonnie Tadlock
Morton, MS

A. G. Williams
Osyka, MS

Joseph W. Gex
Bay St. Louis, MS

S. T. Rayburn
Oxford, MS

Lon Strong
Executive Director

Richard L. Leard
Bureau Director

May 24, 1985

Mr. John D. Kellis
Mississippi Bureau of Geology
P.O. Box 5348
Jackson, MS 39216

Dear Mr. Kellis:

In the event of an oil spill in the coastal waters of Mississippi, protective actions hopefully can be implemented to prevent serious pollution of the environment or at least to minimize the effects of oil pollution. We hope the enclosed publication will contribute to such accomplishments in the event of an oil spill, major or minor.

The publication is entitled "A Contingency Guide to the Protection of Mississippi Coastal Environments from Spilled Oil--Protection Priorities and Related Environmental Information". The composition of the publication was completed earlier by Mr. Jim Franks and myself, however, the printing and binding of it were completed just recently.

The key utility of the publication is that, in the event of an oil spill, it provides guidance for protecting the coastal environmental resources and structures on a prioritized response basis. In addition, the shoreline classifications for the coastal area of Mississippi, as depicted by color, numeric and alphabetic codes, and the other information presented in the publication should have utility beyond protection priorities applicable in the event of an oil spill. As the information from both perspectives may be of interest and utility to you, we are providing the publication to you.

Should you have any questions regarding the contents of the publication, please contact Mr. Jim Franks or me at your earliest convenience.

Sincerely,

Jim Franks
For
Cornell M. Ladner, Ph.D.
Chief, Scientific-Statistical Division

CML:kg

Enclosure

OFFICE OF GEOLOGY

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PART 1. DISCUSSION

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The aim of this document is to provide operational field guidance for implementing protection priority actions applicable to Mississippi coastal environments in the event of an oil spill, particularly, a crude oil spill. This guide to protection priorities has utility relative to small oil spills. However, its greatest usefulness should be realized in the case of a large oil spill threatening an extensive area of habitats and shorelines in parallel with only a limited amount of time, manpower and protective equipment available for preventing oil pollution of the more sensitive environments. In this situation, the predetermined protection priorities would serve as an operational guideline for applying, on a priority basis, available manpower and equipment to protect, to the extent possible, coastal environments in the event of an expansive oil spill.

As opposed to the area-limited protective response to oil threatening an extensive area, when an oil spill threatens to cover only a small area, probably all or most of the protection priorities applicable to that area could be implemented. Thus, from a comparative viewpoint the designated protection priorities take on increasing management value as the area projected to be polluted by a moving oil slick becomes proportionately larger.

The key element of this document consists of the protection priorities designated for coastal habitats and structures. These protection priorities, along with related environmental information, provide guidance for a response in the event spilled oil occurs in the coastal waters of Mississippi.

Seven protection priorities for coastal habitats and structures were developed and are shown on two legends (I and II) on page 2-2 of Part 2. These two legends appear on the page opposite each map in Part 2. Habitats assigned the protection priority number 1 are designated to receive the first (highest) protective efforts whereas structures assigned the protection priority number 7 are designated to receive last attention.

In addition to the specified seven main protection priorities, there may be some management utility in having sub-protection priorities. In Legend I, when more than one coastal habitat or structure occurs within a specified main protection priority, the habitats or structures can be given sub-protection priorities based upon their sequence within the main protection priority. The first habitat or structure listed within a main protection priority can be considered as having the highest sub-protection priority within the group. Within a specified main protection priority and reading from top to bottom, each listed habitat or structure would sequentially have a lower sub-protection priority.

Importantly, it is realized that when there is limited time, equipment and manpower available to respond to an oil spill which threatens to pollute an extensive area, the lower protection priorities would, for practical purposes, not be implemented. Thus, the protective response would be somewhat area-limited. Consequently, the areas receiving protection priority would be those having the greatest sensitivity in combination with areal extent and would be the most difficult to clean up if they were to become polluted. Such a protective response, in essence, demonstrates the justification, value and practical utility for assigning protection priorities.

All legend pages throughout the document are identical. The legends contain the key information of this document. The legends are cross-referenced with the base maps and map inserts and provide a guide to protection priorities.

Legend I shows protection priorities for coastal habitats and structures under ordinary tidal conditions. A description of the coastal habitats and structures is provided along with a designated protection priority number and an alphabetic letter for each described habitat or structure. Additionally, each protection priority number is given a specific color code.

Legend II shows protection priorities under unusually high tidal conditions, such as could occur with high spring tides coupled with strong south or southeast winds.

Base maps and map inserts (higher resolution of selected areas) are also coded in colors and numbers to show the protection priority designated for the respective habitats and structures. The maps also have alphabetic letters which correlate to a specific habitat or structure. The referenced numbers and letters occur as pairs within circles. The colors, numbers and letters are all explained in detail on the legends which occur on the page opposite each respective base map and insert map.

If because of variation in printing quality there is a question as to the color tone on a map in a particular copy of the document, then the designated number in a circle takes priority over the color in determining the protection priority for a given habitat or structure.

The maps are not to be used for navigational purposes.

Table 3-5 in Part 3 contains information on the estimated maximum tidal currents for selected passes (entrances to estuarine areas) in Mississippi coastal waters. This information should be helpful for placing and effectively maintaining booms and other spill response equipment. For instance, this information would be helpful in determining the type of boom and anchoring requirements which would allow stability of the boom while in the presence of a maximum current moving through a pass. Maintaining stable boom operations would provide enhanced control for stopping the movement of spilled oil or, if appropriate, for deflecting it to less sensitive environments.

Tables 3-1, 3-2, and 3-3 in Part 3 present information regarding key aspects of selected commercial, recreational and forage finfish and shellfish species which occur in local coastal waters. Key aspects include spawning periods and spawning locations as well as the times and general locations of occurrence of the adults and early life stages of the selected species. Ready access to such information could aid, in part, in rendering decisions regarding the best operational response to reduce the potential environmental impacts from spilled oil.

Information regarding the location of boat launching sites on the coastal shorelines in Mississippi should be of value to oil spill response personnel for determining boat access to coastal waters. Selected boat launching sites are designated on the maps in Part 2. For information regarding marine facilities located within the Mississippi coastal area, refer to current NOAA nautical charts developed specifically for the local area.

INTRODUCTION

Importance of Mississippi Coastal Environments

The Mississippi coastal estuarine and marine waters and associated shorelines, salt marshes, seagrasses and animal life are extremely valuable assets to the State of Mississippi. These environmental resources (some are shown on the opposite page) and their uses contribute, in part, to a diversified economic base in Mississippi. Specifically, these resources enhance recreational opportunities, provide the base of biological productivity for the commercial and recreational marine fisheries of Mississippi and provide a stimulus to attract tourists to the Mississippi Gulf Coast area.

The commercial and recreational marine fishery and the coastal tourist industry generate approximately $300 million per year to the income of the State of Mississippi. The estimated individual annual contributions are as follows:

Commercial marine fishery--$55 million. (Source: "Fisheries of the United States, 1981", NOAA, National Marine Fisheries Service, 1982.)

Recreational marine fishery--$43.8 million. (Source: "Mississippi Sportsfishing Summary" by U. Fred Deegen and James R. Herring, Mississippi Department of Wildlife Conservation, Bureau of Marine Resources, 1981.)

Coastal tourism--$201.3 million. (Source: U.S. Travel Data Center, Washington, D.C., 1980. Information provided by the Mississippi Board of Economic Development, Division of Tourism and developed from a study entitled "The Economic Impact of Travel in Selected Mississippi Counties, 1978", published in 1980.)

The wealth of $300 million is generally considered to multiply itself at least three times as it works its way through the economy. This wealth is linked to and dependent upon the quality and productivity of the Mississippi Gulf Coast environmental resources. Therefore, it is important that these resources be managed and protected to maintain environmental quality that provides for desired biological productivity and aesthetic value.

Oil and Gas Activities in Coastal Waters

Interest in oil and gas development in the territorial coastal waters of the State of Mississippi and actual oil and gas operations in adjacent state and federal waters are increasing. Also, crude oil and petroleum products are being transported through state coastal waters via tankers, barges and/or pipelines.

The oil operations and oil transportation activities in Mississippi coastal waters and nearby adjacent federal waters increase the risks of spilled oil occurring in Mississippi coastal waters. The probability of an oil spill is low. However, with increasing oil and gas activities in the Mississippi area, prudent environmental management requires that an oil spill response contingency guide be available. The value of the guide is that it facilitates a considerable reduction in field decision-making time, allowing follow-up actions to be rapidly executed to minimize oil pollution impacts in the event an oil spill occurs.

The Composition of this Document

This document is composed of three parts: Part 1 - Discussion, Part 2 - Maps and associated legends and Part 3 - Appendix of supporting information.

The Aim of this Document

The aim of this document is to provide operational field guidance for implementing protection priority actions applicable to Mississippi coastal environments in the event of an oil spill, particularly, a crude oil spill. This guide to protection priorities has utility relative to small oil spills. However, its greatest usefulness should be realized in the case of a large oil spill threatening an extensive area of habitats and shorelines in parallel with only a limited amount of time, manpower and protective equipment available for preventing oil pollution of the more sensitive environments. In this situation, the predetermined protection priorities would serve as an operational guideline for applying on a priority basis, available manpower and equipment to protect, to the extent possible, coastal environments in the event of an expansive oil spill.

As noted, the protection priorities definitely have utility with respect to spilled crude oils. Also, they should have application to some refined/processed crude oil products but their utility may be lessened with respect to some highly refined petroleum products, such as gasoline, spilled in the coastal environment.

For further clarification, the aim of this document was not to present an extensive discussion of the biological and physical systems which characterize the local coastal environment. However, biological highlights and some key physical information are provided.

The Document as a Guideline and Its Value

It should be emphasized that the protection priorities as assigned in this document only serve as a guideline for protective action. However, the guidance, at the detailed resolution provided, should be an extremely valuable asset. The protective guidance, prepared before an oil spill actually occurs, should reduce the amount of critical time applied to on-site decision-making in determining which coastal environments should be given priority for protective action. Therefore, with operational objectives set by the designated protective priorities and in the hands of the On-Scene Coordinator and field personnel, more rapid coordination, assignment and deployment of equipment and manpower should be realized.

This document should be reviewed at least every two years to determine if any updates are needed or if any modifications in the basic guidelines would be appropriate. Until revised, the information as presented in this document can serve as the guide for actions aimed at protecting selected coastal resources of Mississippi in the event spilled oil occurs in coastal waters.

In addition to providing operational guidance for an oil spill response, the coastal environmental information presented in this document may also serve as a helpful source of information for other uses.

The On-Scene Coordinator

As envisioned, the On-Scene Coordinator would have the flexibility to moderate full application of the designated protection priorities or to circumvent the application of them. The flexibility could be exercised based upon specific on-site conditions and operational potential which do not fully align with the designated protection priorities. Flexibility could be exercised under such aspects as changes in the environment subsequent to the preparation of this document; prevailing weather and tidal conditions; types, toxicities, quantities, degree of weathering and expected effects of oil and petroleum products; extent of dispersal of these spilled products into the water column; the direction the oil is projected to take and the extent of the area that could be affected; and available equipment and manpower. Another aspect requiring flexibility in decision-making would be the higher resolution provided by on-scene observations relative to the resolution provided on the maps presented in this document. Another aspect would be the practical utility of and time saved by applying one continual line of protective equipment in front of a relatively small area having environments with different protection priorities, rather than applying several individual protective units to only the environments with the highest protection ratings. There would be other such site-specific conditions under which it would be practical and advantageous for the On-Scene Coordinator to have flexibility for rendering on-scene decisions which may not be entirely consistent with the designated protection priorities.

DOCUMENT DEVELOPMENT

Introductory Comments

The key element of this document consists of the protection priorities designated for coastal habitats and structures. These protection priorities, along with related environmental information, provide guidance for a response in the event spilled oil occurs in the coastal waters of Mississippi. To develop the protection priorities and related resource information, several products were devised and developed and several topics were addressed. These products and topics are described in the following presentation.

Technical Resource Information

An extensive review of literature related to coastal resources was conducted. This literature pertained to environmental/biological information as well as characteristics of petroleum hydrocarbons along with their impacts upon aquatic organisms, communities and environments. Also reviewed was information on oil spill response plans which had been developed for other coastal areas. Additionally, meetings were attended in which oil spill impacts and spill response planning were discussed. Through personal communications, additional information was obtained regarding the Mississippi coastal estuarine environment. Specific and general information was obtained from biologists and environmentalists having experience with these resources.

Photographs and Video Tapes

Photographs of the coastal shorelines (mainland and barrier islands) taken from different altitudes were obtained. These photographs included a color slide taken from satellite photography; 56 high altitude, 9" x 9" National Ocean Survey color photographs; low altitude color as well as black and white photographs taken from a helicopter and a fixed-wing aircraft. Also, ground level color photographs were taken at numerous sites along the coastal shorelines of Mississippi.

During helicopter overflights, video tapes of the coastal shorelines from different perspectives were also developed.

Sediment Sampling and Analysis

A total of 201 surface sediment samples were collected at numerous sites along beach shorelines. The samples were collected by using a three-quarter inch diameter coring tube and were collected to a depth of 12 inches.

The sediment samples were analyzed by a private soil testing laboratory to determine grain size distribution and sediment composition. Samples were first dried in an oven for several hours. Sediment analysis was then conducted via the standard Folk dry sieve, grain size analytical procedure. In this procedure sediment particles are separated on the basis of size. Selected U.S. standard sieve mesh numbers complied with the sieve size classification system prescribed by the U.S. Department of Agriculture.

Grain size data were plotted in phi (Ø) units, following the phi (Ø) scale devised by Krumbein and using the cumulative curve, probability ordinate method. Graphic data were interpreted utilizing the Wentworth Grade Scale which expresses sediment size ranging from boulders to fine-grain sand.

Species Information

Information was obtained on selected coastal finfish and shellfish species having commercial, recreational and forage value. Also obtained was information pertaining to endangered and rare species which occur in the coastal area. The information was derived from various published sources and personal communications.

The key references used are as follows:

1. Benson, N.G., ed. 1982. Life history requirements of selected finfish and shellfish in Mississippi Sound and adjacent areas. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C. FWS/OBS-81/51.
2. Christmas, J.Y., ed. 1973. Cooperative Gulf of Mexico Estuarine Inventory and Study, Mississippi. Gulf Coast Research Laboratory, Ocean Springs, MS 39564.
3. Gulf Coast Research Laboratory, Fisheries Section. 1982. Fisheries Monitoring and Assessment, Completion Report, Project No. 2-296-R. Gulf Coast Research Laboratory, Ocean Springs, MS 39564.
4. Also, information was obtained from several Species Profiles and Habitat Suitability Index Models developed for selected marine finfish and shellfish occurring within the Gulf of Mexico. These documents were recently released by the U.S. Fish and Wildlife Service.

Maximum Tidal Currents Through Passes

Dr. Charles K. Eleuterius of the Gulf Coast Research Laboratory, Ocean Springs, Mississippi, was provided funds to develop estimated maximum tidal currents for selected passes in Mississippi coastal waters. For details of the procedure used and a discussion of the findings, refer to the complete publication presented in Part 3 (the Appendix) under the title of "Estimated Maximum Tidal Currents for Selected Passes in Mississippi Coastal Waters", prepared by Charles K. Eleuterius, April 1984.

Waste Oil Collection Companies

The Mississippi Bureau of Pollution Control, Jackson, Mississippi was contacted to provide a list of companies located on the Mississippi Gulf Coast which are involved in collecting and recycling waste oils.

Development of Maps for Presentation of Information

The protection priorities, the key information in this document, were assigned to selected Mississippi coastal habitats and structures to provide a guide for a protective response to spilled oil. On NOAA National Ocean Survey Nautical Charts which apply to coastal Mississippi and have a scale of 1:40,000, the coastal habitats and structures and their associated protection priorities were then identified by the placement of alphabetic letters (for habitats and structures) and number/colors (for protection priorities). These charts containing the added information are designated as base maps and are presented in Part 2 of this document. NOAA nautical charts were selected for developing the base maps because of their regular use by the U.S. Coast Guard which is responsible for oil spill operational responses in coastal waters. The charts used in producing the base maps were as follows:

NOAA Chart Number	Date Printed	Area Covered
11367	July 23, 1983	Waveland to Catahoula Bay
11372	August 28, 1982	Dog Keys Pass to Waveland
11374	October 16, 1982	Dauphin Island to Dog Keys Pass

As the base maps were produced, slight modifications were made to NOAA charts 11372 and 11374 to update them to approximate the current topography of Ship Island, Horn Island and Petit Bois Island. The modifications were to show physical changes in these barrier islands which did not appear on the charts as printed in 1982.

In addition to the developed base maps, portions of several USGS 7.5 minute topographic maps having a scale of 1:24,000 were used to provide higher resolution of selected coastal areas. These maps are designated as map inserts and they also appear in Part 2 of this document.

As with the base maps, on the insert maps the locations of coastal habitats and structures were identified by color-codes which correlate with protection priorities. Habitats and structures were also coded with numbers which corrrespond to the protection priorities and with letters which correspond to a specific habitat or structure. In addition to protection priorities, other related environmental information was also portrayed on the maps.

The maps were color-separated using a laser scanner. The legends associated with the maps as well as photographs were also color-separated using a laser scanner. From the color separations, the final color products were produced.

Principle Concepts for Development of Protection Priorities

The protection priorities are the key component and focal point of this guidance document. Seven protection priorities for coastal habitats and structures were developed and are shown on two legends on page 2-2 of Part 2. These two legends appear on the page opposite each map in Part 2. Habitats assigned the protection prioritiy number 1 are designated to receive the first (highest) protective efforts whereas structures assigned the protection priority number 7 are designated to receive last attention. Again, it should be realized that the protection priorities only serve as a guideline for protective actions.

The protection priorities are primarily based upon the following: the relative sensitivity of environmental features (the coastal habitats and structures) to spilled oil; the relative size and location of the sensitive environment; the ease or difficulty in removing oil from contaminated environments; in cases, the potential of oil contaminating one environment to be transported over a relatively low, natural barrier, consequently polluting another more extensive and sensitive environment.

To illustrate how the protection priorities for coastal environmental features were assigned based upon the aforementioned primary differentiating factors, consider a comparison of two specific features: exposed expansive salt marshes subject to ordinary tidal inundation (labelled "D" on the legend page) and concrete seawalls (labelled "R" on the legend page). Environment "D" was assigned a protection priority of 2 while the seawall (R) was assigned a protection priority of 7. The difference in assigned protection priorities is largely based upon the differences in sensitivity of these environmental features to spilled oil and in clean-up characteristics.

As a result of heavy, wide spread oil pollution, published literature documents that the salt marsh environment (D) would be negatively impacted in the form of reduced biological productivity and would be very difficult, if not impossible, to clean up. Furthermore, the oil in the salt marsh could be expected to negatively impact it for several years. In comparison, the negative impact of the oil on the concrete seawall (R) would be of less concern. Also, oil could be easily removed from the relatively smooth-surfaced seawall or, while in the vicinity of the wall and if floating on the surface of the water, the oil could be corralled and collected without great environmental concern for protective efforts to prevent oil pollution on the seawall.

The differentiating factors clearly justify the rationale for giving the salt marsh (D) a considerably higher protection priority than the concrete seawall (R).

Barrier island passes and openings to rivers, bays, bayous and tidal creeks (labelled "A"), all leading to exposed or sheltered salt marshes and very shallow estuarine waters, are given the highest protection priority. This priority is required because if oil moves through these passes and openings, highly sensitive, extensive and biologically productive coastal habitats could become polluted with oil and thus be negatively impacted for a long period of time. The negative environmental impact could then produce an undesirable economic impact.

The barrier island passes serve as a primary line of defense for attempting to control movement of oil from waters of the Gulf into the Mississippi Sound. For this reason and for the reasons previously mentioned, the barrier island passes have been included in the highest protection priority, designated number 1.

Furthermore, if oil moves into the Mississippi Sound or is spilled directly in the Sound and then moves into rivers, bays, bayous and tidal creeks having associated tidal marshes, two marsh shorelines could be polluted by the oil as it moves up any one of these aquatic environments. Consequently, for any one of these aquatic environments, the area of marsh impacted by the oil could be two-fold greater than would be the area impacted on a frontal tidal marsh of an equal length but having only its one edge exposed to oil present in open Mississippi Sound waters. For this additional reason, openings to rivers, bays, bayous and tidal creeks having associated tidal marshes have been included in the highest protection priority, designated number 1.

Large (B), medium (F) and small (J) size oyster beds are given protection priorities of 1, 2 and 3, respectively. As oyster beds decrease in size, their relative value and replacement cost also decrease. This decrease provides a differential for protection priorities having practical management utility, especially when there is limited time, manpower and equipment available to respond to a wide-spreading oil slick.

For habitat "G", the relative size of the frontal salt marsh and the expansive salt marsh beginning immediately behind the low, narrow berm were key factors for assigning this habitat a protection priority of 3.

For habitats "H" and "I", the porosity of the components combined with the lack of clean-up opportunities or the difficulty in clean-up operations were factors which suggested that these habitats should be given a protection priority of 3.

For habitat "K", the known difficulty in removing oil from the associated porous internal structures and numerous vessels suggested that marina and harbor openings also should be given the protection priority 3. Importantly, preventing oil from moving into marinas and harbors would circumvent a problem which would otherwise involve chronic tidal flushing of oil back into adjacent open waters.

For habitat "L", the relatively small size of the salt marshes and the presence of elevated lands located behind them were key factors for assigning this habitat a protection priority of 4.

Habitat "M" was given a slightly higher protection priority than habitat "N" on the premise that the narrower sand beaches of "M" provided less of a protective barrier to the marshes located immediately behind the beaches.

Allowing oil to settle on fine-sand beaches is generally considered to be a favored priority for an oil spill response. (For an explanation, under Part 1 see the following section entitled "Protection Priorities and Associated Informational Highlights", subsection labelled "Legends".) If the sandy beaches of "M" are allowed to become oiled, the longer the oil remains on these narrow sandy beaches the greater is the risk of a high tide occurring that would wash the oil over the narrow beach into the valuable marsh located immediately behind the beach. Such risks are somewhat reduced for the exposed, wide sand beaches of "N". Because of these differences, habitats "M" and "N" were given slightly different protection priorities.

In addition to the specified seven main protection priorities, there may be some management utility in having sub-protection priorities. In Legend I, when more than one coastal habitat or structure occurs within a specified main protection priority, the habitats and structures can be given sub-protection priorities based upon their sequence within the main protection priority. The first habitat or structure listed wihtin a main protection priority can be considered as having the highest sub-protection priority within the group. Within a specified main protection priority and reading from top to bottom, each listed habitat or structure would sequentially have a lower sub-protection priority.

Importantly, it is realized that when there is limited time, equipment and manpower available to respond to an oil spill which threatens to pollute an extensive area, the lower protection priorities would, for practical purposes, not be implemented. Thus, the protective response would be somewhat area-limited. Consequently, the areas receiving protection priority would be those having the greatest sensitivity in combination with areal extent and would be the most difficult to clean up if they were to become polluted. Such a protective response, in essence, demonstrates the justification, value and practical utility for assigning protection priorities.

As opposed to the area-limited protective response to oil threatening an extensive area, when an oil spill threatens to cover only a small area, probably all or most of the protection priorities applicable to that area could be implemented. Thus, from a comparative viewpoint the designated protection priorities take on increasing management value as the area projected to be polluted by a moving oil slick becomes proportionately larger.

Photographs of Selected Habitats and Structures Located Within the Coastal Environment of Mississippi and the Protection Priority Designated to Each

Two pages of these photographs are provided at the end of Part 1. The number shown at the bottom of each photograph represents the designated protection priority for the specific habitat or structure which is identified by a letter. Also provided is a description of the habitat or structure and its location in the coastal area of Mississippi. The information presented in these photographs should be a valuable aid for visualizing the habitats and structures identified on the maps.

THE PROTECTION PRIORITIES AND ASSOCIATED INFORMATIONAL HIGHLIGHTS

Discussion of Part 2 Components (The components are presented on pages 2-1 to 2-33.)

Index to Base Maps

This index is shown on page 2-1 of the document. The index identifies the coastal area of Mississippi covered by twelve base maps. Each base map provides a small amount of overlap with associated base maps.

Legends

Following the "Index to Base Maps" are two legends which are designated as I and II and are shown on page 2-2. All legend pages throughout the document are identical. The legends contain the key information of this document. The legends are cross-referenced with the base maps and map inserts and provide a guide to protection priorities applicable in the event oil is spilled in the coastal waters of Mississippi or in open Gulf waters and is then transported into the coastal waters.

To facilitate rapid and easy use during field operations, a legend page containing Legends I and II has been placed on the page opposite each base map and map insert.

Legend I shows protection priorities for coastal habitats and structures under ordinary tidal conditions. A description of the coastal habitats and structures is provided along with a designated protection priority number and a letter for each described habitat or structure. Additionally, each protection priority number is given a specific color code.

The letters, numbers and color codes as presented in Legend I are also presented, where applicable, on the base maps and map inserts.

Legend II shows protection priorities under unusually high tidal conditions, such as could occur with high spring tides coupled with strong south or southeast winds. Tropical storm or hurricane conditions are excluded from consideration. As can be seen, three types of habitats shift to higher protection priorities under unusually high tidal conditions.

Because of the variability in the presence and absence of tidal flats, they are not given protection priority numbers in the legends. In general, when tidal flats occur, they should be given the same protection priority as the habitat or structure adjacent to them and located at the higher elevation of tidal influence. The exception could be tidal flats in areas associated with structures designated with a protection priority of 7. Such tidal flats when present could be given a protection priority of 4.

As noted on the bottom of Legend I, sediment analyses show Mississippi sand beaches to be of a medium to fine texture.

Grain size of beach sediments is an important factor relative to the management of spilled oil. As the grain size increases, the porosity of the sediment increases and correspondingly, oil penetrates to greater depths in the sediment. Thus, the impact of oil on a very coarse-textured beach, for example a rocky beach, would be greater than on a fine-textured beach. Consequently, it is preferable to direct oil to smaller grain size beaches where it largely remains on the surface of the sediment. Efforts can be initiated to remove the oil, or depending upon location, it may be allowed to weather on the sand. If allowed to weather, the leather-like weathered product can be removed more easily than fresh oil. After removal it would be transported to an appropriate disposal site.

Spilled oil reaching the Mississippi coastal sand beaches would cause relatively minimal environmental impacts since these beaches are of a medium to fine texture. The environmental impacts from oil reaching these beaches would be magnitudes less than the environmental impacts resulting from oil contaminating salt marshes. Furthermore, the beaches can be cleaned whereas clean-up efforts in salt marshes are essentially impractical.

In further discussion of the legend page, at the bottom other environmental information (shorebird nesting sites, migratory waterfowl wintering habitat and boat launching sites) is presented and given identification symbols. The symbols identify the respective resources on the base maps and map inserts.

Also, at the bottom of the legend page the least tern (Sterna antillarum) is characterized as having threatened status. Subsequent to the printing of the legend page, clarification was obtained regarding the current official status of the least tern. Presently, it is officially classified as a rare species by the Mississippi Wildlife Heritage Program.

Boat Launching Sites

Information regarding the location of boat launching sites on the coastal shorelines of Mississippi should be of value to oil spill response personnel in determining boat access to coastal waters. For information regarding marine facilities located within the Mississippi coastal area, refer to current NOAA nautical charts developed specifically for the local area. The following boat launching sites are designated on the Maps in Part 2 by this symbol

HANCOCK COUNTY
(from west to east)

LaFrance Fish Camp
Route 2, Box 451
Bay St. Louis, MS 39520
Phone No. (601) 467-9180
Mr. S. T. Hall, Manager

Bayou Caddy Harbor
South end of South Beach Blvd.
Waveland, MS

HARRISON COUNTY
(from west to east)

Bayou Portage Fish Camp
Route 5, Box 830
Pass Christian, MS 39571
Phone No. (601) 452-7561
Mr. Fred Martin, Manager

Bayview Marina
103 Bayview Drive
Pass Christian, MS 39571
Phone No. (601) 452-7390
Mr. Joe Bowen, Manager

Pass Christian Small Craft Harbor
Highway 90
Pass Christian, MS 39571
Phone No. of Harbor Master
(601) 452-7956

Long Beach Harbor
Highway 90
Long Beach, MS 39560
Phone No. of Harbor Master
(601) 863-4795

Gulfport Small Craft Harbor
Highway 90
Gulfport, MS 39501
Phone No. of Harbor Master
(601) 868-5713

Broadwater Marina
Highway 90
Biloxi, MS 39533
Phone No. of Harbor Master
(601) 388-3663

Biloxi Small Craft Harbor
Highway 90
Biloxi, MS 39530
Phone No. of Harbor Master
(601) 436-4062

Terminus of Oak Street at Biloxi Bay
South of Highway 90, East Biloxi
Biloxi, MS

JACKSON COUNTY
(from west to east)

Ocean Springs Harbor
Front Beach Drive
Ocean Springs, MS

Gulf Islands National Seashore
Davis Bayou Headquarters
Ocean Springs, MS 39564
Phone No. (601) 875-0823

Old Shell Landing
Hammil Farm Road
Off Old Highway 90 East
Ocean Springs, MS

Mary Walker Fishing Camp and Marina
Mary Walker Drive
Off Highway 90
Gautier, MS 39553
Phone No. (601) 497-3141

Tucei's Fish Camp
Oak Street
Gautier, MS 39553
Phone No. (601) 497-4426

Lake Yazoo Launching Area
West end of Beach Blvd.
Pascagoula, MS

Bayou Cumbest Bait Shop
Route 1, Box 1098
Pascagoula, MS 39567
Phone No. (601) 475-1310
Mr. Charles English, Manager

Maps

In Part 2 there are maps termed for identification purposes as base maps and map inserts. The base maps are at a lower scale than are the map inserts.

There are twelve base maps. These maps cover the Mississippi coastal mainland with its shoreline and inlets as well as the barrier islands located in Mississippi coastal waters. The specific areas covered by individual base maps are shown on the "Index to Base Maps" on page 2-1.

There are four map inserts. These map inserts are expansions of selected areas on four of the base maps and provide for a higher resolution. Each map insert immediately follows the base map with which it is associated. Base map and map insert numbers appear on the center righthand edge of each map page.

All of these maps are coded in colors and numbers to show the protection priority designated for the respective habitats and structures. The maps also have letters which correlate to a specific habitat or structure. The referenced numbers and letters occur as pairs within circles. The colors, numbers and letters are all explained in detail in the legends which occur on the page opposite each respective base map and insert map.

Two important statements pertain to these maps. First, the maps are not to be used for navigational purposes. Secondly, if because of variation in printing quality there is a question as to the color tone in a particular copy of the document, then the designated number in a circle takes priority over the color in determining the protection priority for a given habitat or structure.

DISCUSSION OF PART 3 COMPONENTS

(The components are found on pages 3-1 to 3-10.)

Commercial, Recreational and Forage Species

(See Tables 3-1, 3-2, and 3-3 in Part 3)

In considering a response aimed at reducing environmental impacts of an oil spill in the coastal area of Mississippi, it would be valuable to have on hand some information regarding key aspects of selected commercial, recreational and forage finfish and shellfish species which occur in local coastal waters. Key aspects include spawning periods and spawning locations as well as the times and general locations of occurrence of the adults and early life stages of the selected species. Ready access to such information could aid, in part, in rendering decisions regarding the best operational response to reduce the potential environmental impacts from spilled oil.

Therefore, within general areas of Mississippi coastal waters and for selected coastal finfish and shellfish species having commercial, recreational and forage value, spawning periods and spawning locations for these species were summarized and are presented in Table 3-1 in Part 3. Also, monthly occurrences of adults and early life stages of key species are summarized in Table 3-2 in Part 3. Furthermore, in Table 3-3 life history highlights are presented for representative coastal finfish and shellfish species.

Endangered and Rare Species

Table 3-4 in Part 3 is a listing of endangered and rare species known to occur in Mississippi's coastal counties and associated waters. Having ready access to this information could be valuable in planning and responding to spilled oil occurring in Mississippi coastal waters.

Maximum Tidal Currents Through Passes

(See Table 3-5 in Part 3)

In the event of an oil spill, a key action in preventing oil pollution of coastal habitats would be the placement of booms or other spill response equipment in critical water passage areas. In cases, booms and other equipment may be placed to stop the movement of the oil so that it can be immediately collected. In other cases, the response equipment may be placed in a manner to deflect the oil away from highly sensitive habitats to an area of less environmental sensitivity where it can be readily collected.

To aid in placing and effectively maintaining booms and other spill response equipment, it would be highly valuable to have an estimate of the maximum tidal current that would be expected to move through an individual pass. For instance, this information would be helpful in determining the type of boom and anchoring requirments which would allow stability of the boom while in the presence of a maximum current moving through a pass. Maintaining stable boom operations would provide enhanced control for stopping the movement of spilled oil or, if appropriate, for deflecting it to less sensitive environments.

Table 3-5 in Part 3 is actually a publication developed specifically for this document and contains information on the estimated maximum tidal currents for selected passes (entrances to estuarine areas) in Mississippi coastal waters. Tidal currents for barrier island passes are not included in the publication. For each selected pass, information is presented on its width, cross-section area, average depth, maximum depth, perimeter, maximum inflow in knots and maximum outflow in knots. Also, Table 3-5 contains maps (Figures 1-7) showing the respective transect lines for each selected pass. The table also contains a discussion of the methods used to arrive at the information as presented.

Waste Oil Companies

Table 3-6 in Part 3 presents a list of companies located on the Mississippi Gulf Coast which are involved in collecting waste oils. These companies have facilities for the deposition of spilled oil collected from environments in the coastal area of Mississippi.

FOLLOW-UP DOCUMENT(S)

During preparation of this document, the emphasis was on identifying and showing on maps the locations of Mississippi's coastal habitats and structures and assigning protection priorities to them. The protection priorities would be used as a guide for a protective response in the event spilled oil threatens to pollute the coastal habitats and structures.

A follow-up document(s) is needed to complement this document. The topics addressed in the follow-up document(s) should include but not be limited to the following:

1. Operational infrastructure for a coordinated effort involving, as needed, available personnel and equipment resources to be used in implementing an effective response to an oil spill in the coastal area of the State of Mississippi. Presently, the On-Scene Coordinator for the State of Mississippi is located within the Mississippi Department of Natural Resources in its Bureau of Pollution Control, Jackson, Mississippi.
2. Specific field operational strategies and mechanisms applicable to specific types of oils and varying environmental conditions in order to protect resources in accordance with the guidance protection priorities presented in this document.
3. Dispersants and the conditions, if any, under which they could be advantageously utilized.
4. Damage assessment and guidelines for determining compensation for damage to environmental resources caused by spilled oil.

ACKNOWLEDGEMENTS

The authors would like to acknowledge persons who provided assistance during the development and preparation of this document.

We thank fellow employees of the Bureau of Marine Resources (BMR) who assisted in some of the field activities.

Richard McCann assisted in the compilation of biological resource information. Andrew Leingang and Samuel Johnson provided useful suggestions and considerable artistic assistance in placing the numbers, stippling and colors used to code the maps.

We thank David Sykes of the Gulf Coast Mosquito Control Commission for use of the Commission's helicopter in acquiring aerial photographs and video tapes of Mississippi's coastal environment. We also thank Terese Collins of the BMR for video taping the coastal resources pertaining to this document.

Appreciation is extended to Dr. Richard Leard, Director of the BMR, as well as the Division Chiefs and Scientific Staff of the Bureau, who participated in the document review process.

Other persons participated in the review of draft materials and provided comments. These persons are listed as follows:

Colonel Charlie Blalock, Mississippi Department of Natural Resources.
John Harper, Mississippi Bureau of Pollution Control.
LCDR James Tanner, U.S. Coast Guard - Gulf Strike Team.
Dr. Edwin Keppner, National Marine Fisheries Service (Southeast Region).
Larry Goldman, U.S. Fish and Wildlife Service.
Sheppard Moore, Environmental Protection Agency (Region IV).
Glade Woods, Consulting Engineer and former Manager, Office of Marine Pollution Assessment, NOAA, Bay St. Louis, MS.
We thank Dr. Terry McBee of the Gulf Coast Research Laboratory (GCRL), Ocean Springs, Mississippi, who served as the coordinator for a review of draft materials among the Laboratory's scientific staff. We appreciate the constructive comments offered by Laboratory reviewers.

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We thank BMR secretaries Mary Crosby, Kathleen Graham and Becky Hair for typing the information which was used by the printer in developing the final products.

Southern Mississippi Planning and Development District, Gulfport, Mississippi is to be thanked for printing and binding the document. Special thanks go to Frank Jones, Scott Batson, Linda Laird and Regina Melton.

PHOTO CREDITS

Photographic work was performed by James Franks, Terese Collins, Dianne Hunt and Chris Snyder of the BMR and Cynthia Kennedy of Kennedy Camera, Biloxi, Mississippi.

Photographs of Selected Habitats and Structures Located Within the Coastal Environment of Mississippi and the Protection Priority Designated for Each

Protection Priority 1A. Horn Island Pass. Looking west from tip of Petit Bois Island to Horn Island; the large spoil island is located within the Pass. The Gulf of Mexico is shown to the left of the islands and Mississippi Sound to the right (April 1984). See Map 11.

Protection Priority 1A. Opening to Three Oaks Bayou, Hancock County (March 1983). See Map 1.

Protection Priority 1A. Openings (see arrows) to I) Point aux Chenes Bay and II) Middle Bay, both located in Jackson County (January 1982). See Map Insert 3.

Protection Priority 2D. Exposed, expansive salt marsh which is typical of the eastern shoreline of Heron Bay, Hancock County (August 1983). See Map 1.

Protection Priority 2D. Exposed, expansive salt marsh located along northern shoreline of Middle Bay, Jackson County (August 1983). The marsh extends to the distant tree line. See Map Insert 3.

Protection Priority 3G. Shoreline north of Shrimp Bayou, Hancock County (March 1983). See Map 1.

Protection Priority 3I. Riprap located on west side of Long Beach Harbor, Harrison County (March 1982). See Map 3.

Protection Priority 4L. Shoreline at Gulf Islands National Seashore - Davis Bayou Area, Jackson County (August 1983). See Map Insert 1.

Protection Priority 4M. Shoreline at Point aux Chenes, Jackson County (August 1983). See Map 6.

Protection Priorities as shown from west to east (left to right): 50, 4M, and 1A. Shoreline at Bellefontaine Point - Graveline Lake area, Jackson County (January 1982). See Map 5.

Protection Priority 5N. Southern shoreline of Petit Bois Island (looking west), showing salt marsh areas behind the wide sand beach (March 1983). See Map 11.

Protection Priority 50. Wide, man-made sand beach located west of Biloxi, Harrison County (August 1983). See Map 4.

Protection Priority 6Q. Long public fishing pier (Westside Community Pier) located west of Gulfport, Harrison County (August 1983). See Map 3.

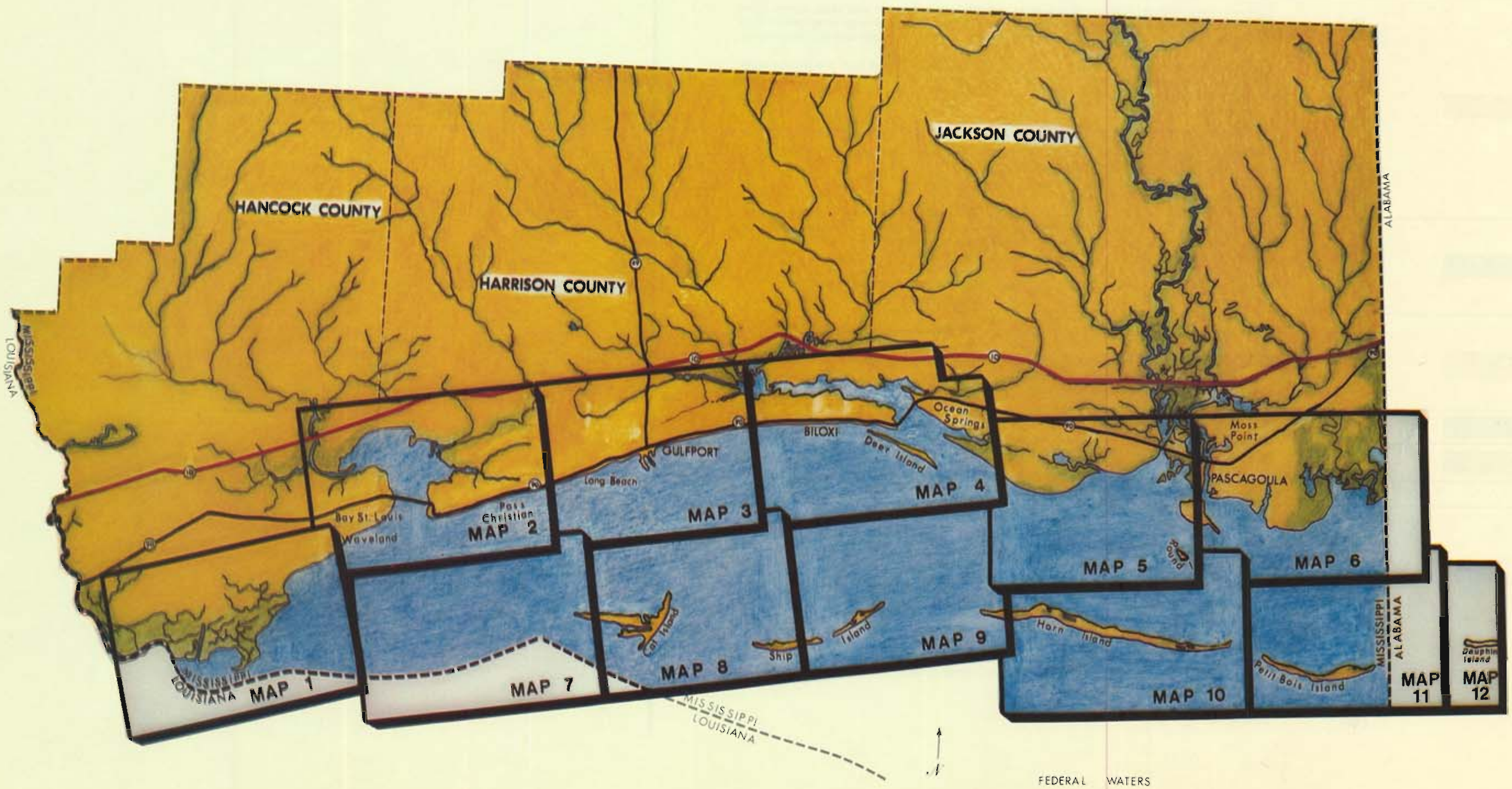
Protection Priority 7R. Concrete seawall along North Beach Boulevard at western shoreline of St. Louis Bay, Hancock County (August 1983). See Map 2.

PART 2. MAPS

INDEX TO BASE MAPS 1-12

As a guide, the maps show protection priorities for specific habitats and structures in the event oil is spilled in Mississippi coastal waters.

There are also four map inserts which provide a greater resolution of specific areas on four of the base maps. Each map insert immediately follows the base map with which it is associated.



LEGENDS I AND II

A Guide to Protection Priorities Applicable in the Event Oil is Spilled in the Coastal Waters of Mississippi

Legend I. Protection Priorities Under Ordinary Tidal Conditions

Protection Priorities (1=highest priority)	Identification Letters	Description of Coastal Habitats and Structures
1	A	Barrier island passes; openings to rivers, bays, bayous and tidal creeks, all leading to exposed or sheltered salt marshes and very shallow estaurine waters.
	B	Large size, natural oyster beds and closely associated smaller beds (Dotted stippling on maps).
	C	A shallow, subtidal bottom that extends out to the 4-foot depth contour and attracts unusually high concentrations of early life stages of finfish and shellfish. (This exceptionally productive nursery ground is located off the Bellefontaine Point area, Jackson County.) This area also serves as an important wintering site (from November to April) for large numbers of various species of migratory ducks.
2	D	Exposed, expansive salt marshes subject to ordinary tidal inundation.
	E	Seagrass beds and attached macroscopic algal communities (Habitats shown on maps by parallel stippling).
	F	Medium size, natural oyster beds (Dotted stippling on maps).
3	G	Exposed, narrow bands of salt marsh subject to ordinary tidal inundation with a low, narrow berm located immediately behind the salt marsh and with an expansive marsh beginning immediately behind the berm. Also, exposed, moderate size salt marshes subject to ordinary tidal inundation.
	H	Sharply-rising shell beaches extending landward approximately 50 feet from the water's edge with an expansive marsh beginning immediately behind the shell beaches. (These beaches are restricted to an area south of Three Oaks Bayou, Hancock County.)
	I	Riprap.
	J	Small size, natural oyster beds and commercial oyster lease sites (Dotted stippling on maps with commercial sites shown by rectangular shapes).
	K	Openings to marinas and harbors.
4	L	Exposed, narrow bands of salt marsh subject to ordinary tidal inundation with elevated lands located behind them. In cases, a narrow sandy beach may occur between the bands of marsh and the elevated lands.
	M	Exposed, narrow sand beaches* with expansive salt marsh areas beginning immediately behind the beaches.
5	N	Exposed, wide sand beaches* with salt marshes located immediately behind the beaches.
	O	Exposed sand beaches* with elevated lands located behind the beaches.
	P	Inlets to areas with little or no marsh habitat.
6	Q	Long fishing piers on pilings.
7	R	Concrete seawalls and other solid bulkheads, and wharfs.

*Sediment analyses show sand beaches to be of a medium to fine texture.

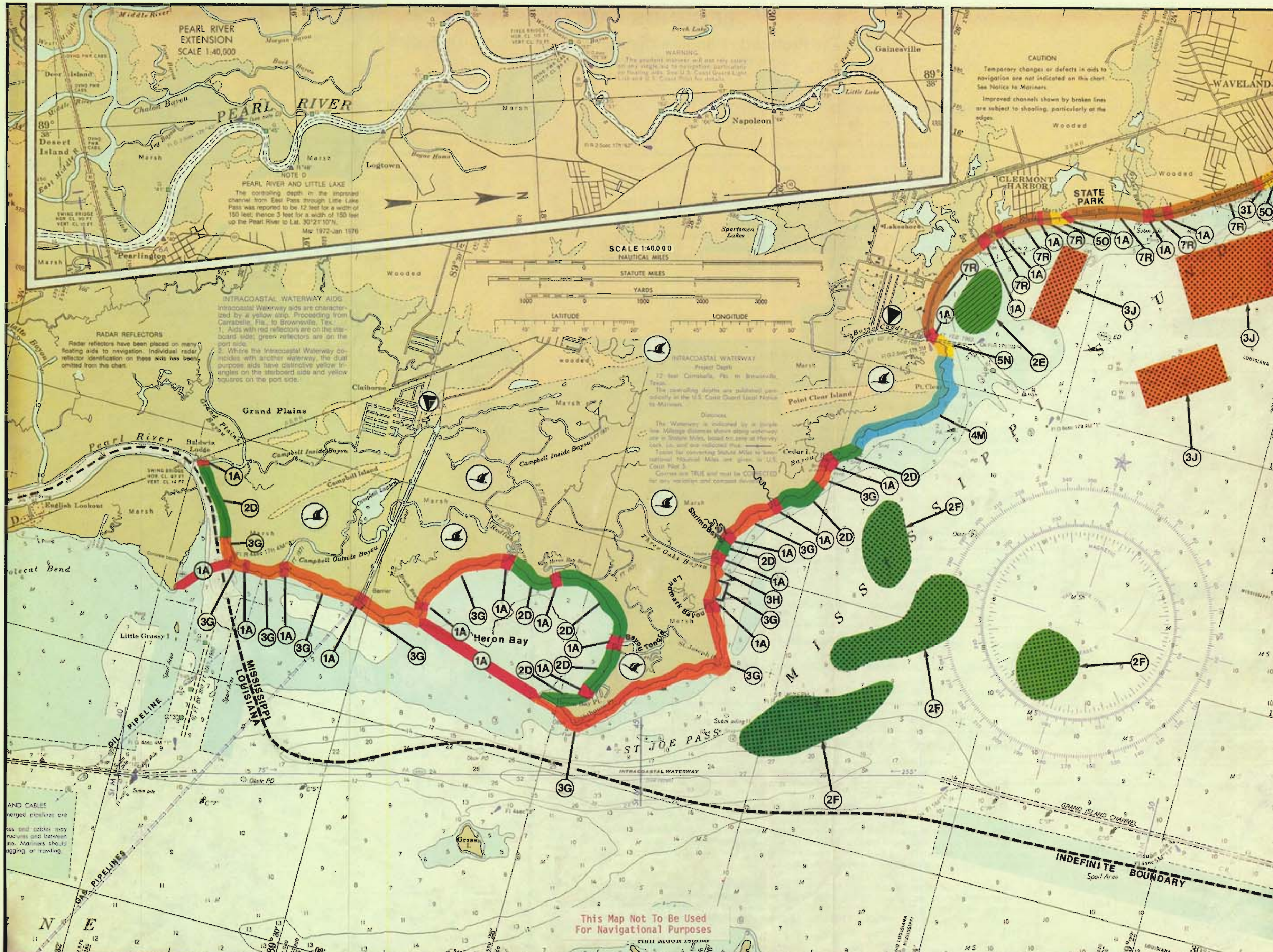
Identification Symbols	Related Environmental Information
	Sand beach locations where shorebirds (e.g. terns, gulls, and skimmers) nest in concentrations and raise their young from April through August. Nesting sites are not subject to oil pollution under ordinary tidal conditions. Due to the "threatened" status of the least tern, primary nesting sites of this species are specifically identified on the maps.
	Migratory waterfowl wintering habitat. The following expansive salt marsh areas serve as wintering sites (from November to April) for migratory waterfowl and are designated on the maps: (1) southernmost Hancock County (from the Pearl River to Point Clear, approx. 13,000 acres) and (2) southeastern Jackson County (from Point aux Chenes to the Middle Bay area, approx. 9,000 acres).
	Boat launching sites.

Legend II. Protection Priorities Under Unusually High Tidal Conditions

Identification Letters and Protection Priorities Under Ordinary Tidal Conditions (See descriptions in Legend I)	Shift in Protection Priorities (a)	New Protection Priorities Under Unusually High Tidal Conditions
3G	→	2
4M	→	2
5N	→	2

(a) Only the coastal habitats which shift in Protection Priorities are shown. Those not shown retain the Protection Priorities assigned under ordinary tidal conditions.

Protection Priorities shift when tidal waters are flooding or are expected to flood over the specified berms or sand beaches and when spilled oil is projected to move in the direction of salt marsh areas located behind the flooded berms or sand beaches.


PEARL RIVER
EXTENSION
SCALE 1:40,000
PEARL RIVER
NOTE D
PEARL RIVER AND LITTLE LAKE
Mar 1972-Jan 1976
Logtown
Napoleon
Gainesville
Little Lake
Pearlington
Desert Island
Deer Island
Chalon Bayou
Perch Lake
WARNING
CAUTION
Temporary changes or defects in aids to navigation are not indicated on this chart. See Notice to Mariners.
Improved channels shown by broken lines are subject to shoaling, particularly at the edges.
Wooded
WAVELAND
CLERMONT HARBOR
STATE PARK
Lakeshore
Sportsmen Lakes
SCALE 1:40,000
NAUTICAL MILES
STATUTE MILES
YARDS
LATITUDE
LONGITUDE
INTRACOASTAL WATERWAY AIDS
RADAR REFLECTORS
INTRACOASTAL WATERWAY
Claiborne
Grand Plains
Pearl River
Baldwin Lodge
Campbell Inside Bayou
Campbell Island
English Lookout
Marsh
Campbell Outside Bayou
Point Clear Island
Cedar I.
Shrimp Bayou
Three Oaks Bayou
Landmark Bayou
Heron Bay
St. Joseph
Polecat Bend
Little Grassy I
MISSISSIPPI
LOUISIANA
OIL PIPELINE
GAS PIPELINES
ST JOE PASS
INTRACOASTAL WATERWAY
GRAND ISLAND CHANNEL
INDEFINITE BOUNDARY
Spoil Area
Grassy I
This Map Not To Be Used
For Navigational Purposes
MISSISSIPPI
SOUND

BASE
MAP
1

LEGENDS I AND II

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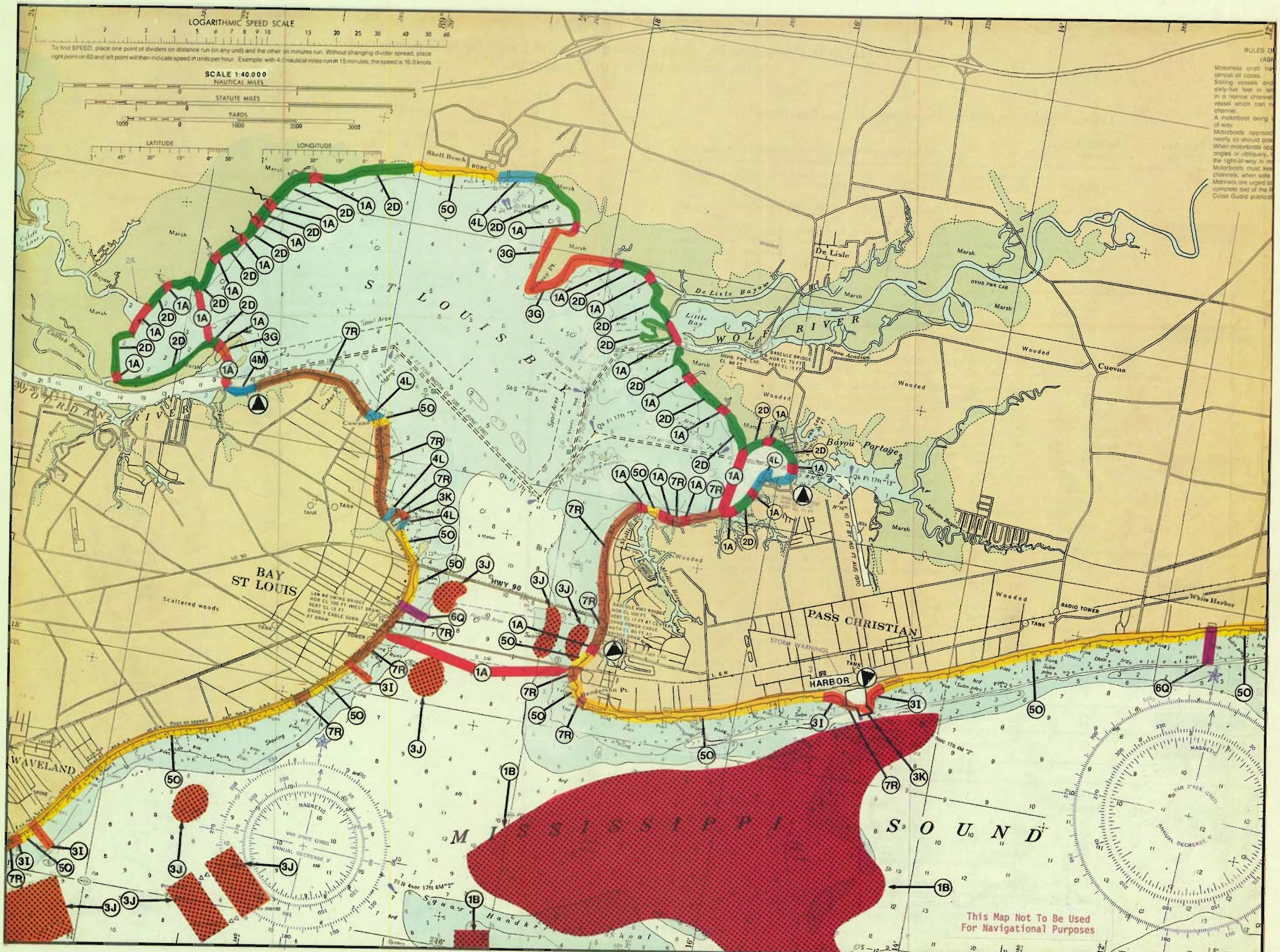
LOGARITHMIC SPEED SCALE
SCALE 1:40,000
NAUTICAL MILES
STATUTE MILES
YARDS
LATITUDE
LONGITUDE
Shell Beach
Marsh
ST LOUIS BAY
De Lisle
De Lisle Bayou
Little Bay
WOLF RIVER
Bayou Acadian
Wooded
Cuevas
Bayou Portage
JOURDAN RIVER
Cowan
BAY ST LOUIS
Scattered woods
HWY 90
PASS CHRISTIAN
HARBOR
RADIO TOWER
TANK
White Harbor
Henderson Pt.
WAVELAND
MISSISSIPPI SOUND
Square Handkerchief Shoal
MAGNETIC
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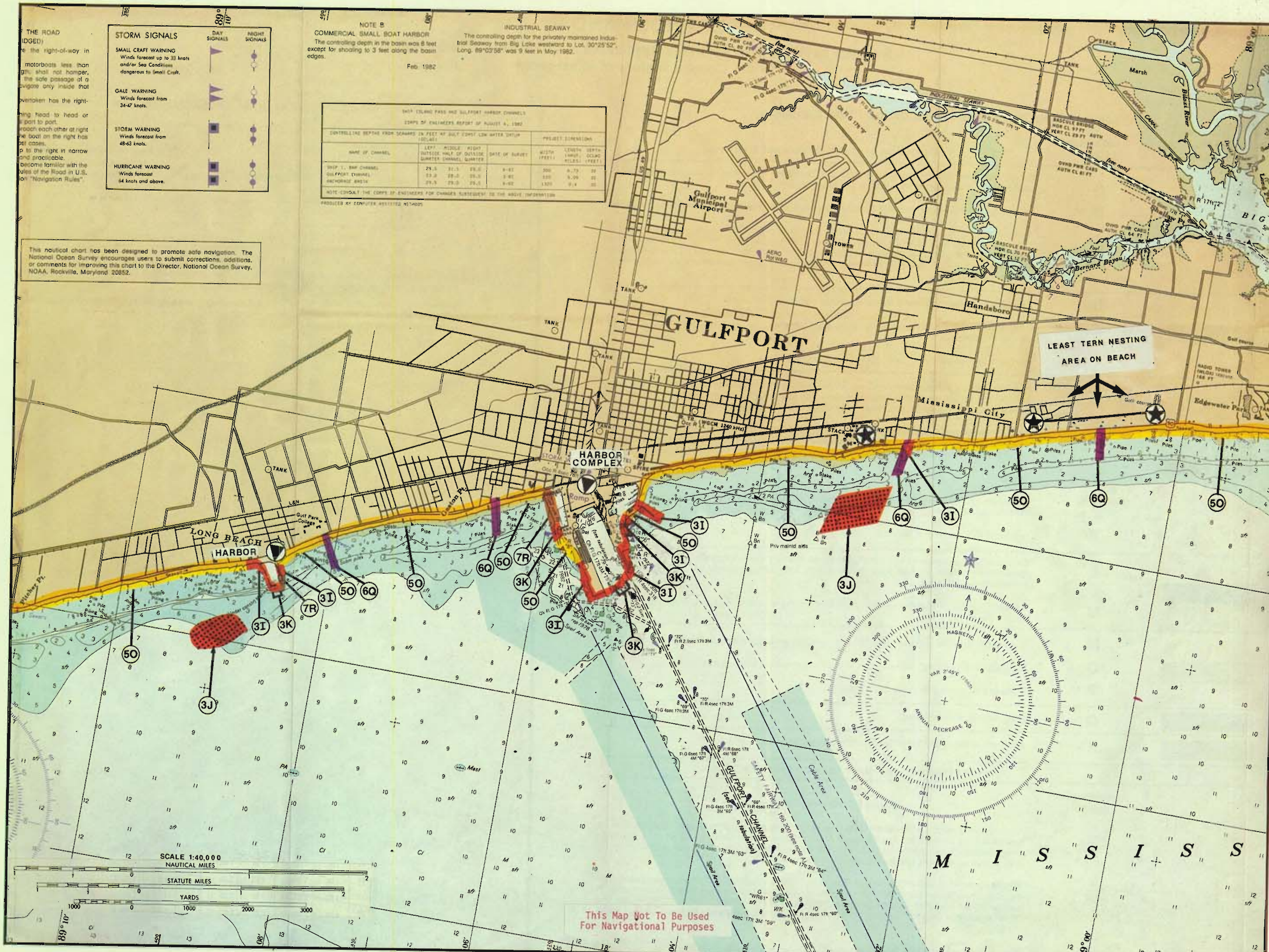
STORM SIGNALS
DAY SIGNALS
NIGHT SIGNALS
SMALL CRAFT WARNING
Winds forecast up to 33 knots and/or Sea Conditions dangerous to Small Craft.
GALE WARNING
Winds forecast from 34-47 knots.
STORM WARNING
Winds forecast from 48-63 knots.
HURRICANE WARNING
Winds forecast 64 knots and above.
NOTE B
COMMERCIAL SMALL BOAT HARBOR
The controlling depth in the basin was 8 feet except for shoaling to 3 feet along the basin edges.
Feb 1982
INDUSTRIAL SEAWAY
The controlling depth for the privately maintained Industrial Seaway from Big Lake westward to Lat. 30°25'52", Long. 89°03'58" was 9 feet in May 1982.
This nautical chart has been designed to promote safe navigation. The National Ocean Survey encourages users to submit corrections, additions, or comments for improving this chart to the Director, National Ocean Survey, NOAA, Rockville, Maryland 20852.
Gulfport Municipal Airport
GULFPORT
Handsboro
Mississippi City
Edgewater Park
Marsh
Biloxi River
Bernard Bayou
INDUSTRIAL SEAWAY
LEAST TERN NESTING AREA ON BEACH
HARBOR COMPLEX
LONG BEACH
HARBOR
Gulf Park College
Courthouse Rd.
Pass Christian
MAGNETIC
GULFPORT CHANNEL
SAFETY FAIRWAY
Cable Area
Spoil Area
M I S S I S S
SCALE 1:40,000
NAUTICAL MILES
STATUTE MILES
YARDS
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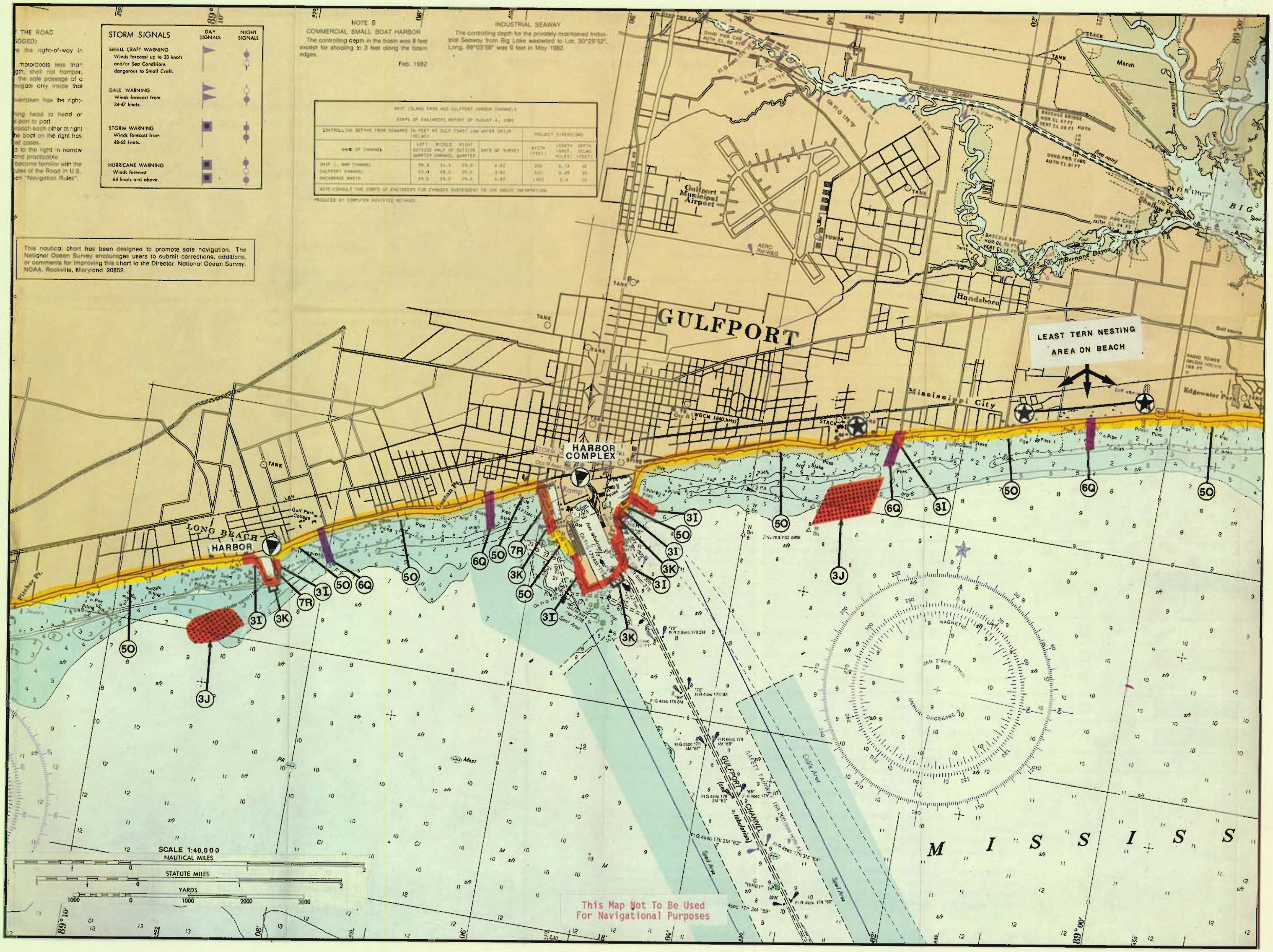
3I
3J
3K
5O
6Q
7R

BASE MAP 3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Gulf Park College
Edgewater Park
Marsh
INDUSTRIAL SEAWAY
Bernard Bayou
BIG
TANK
TOWER
STACK
3I
3K
3J
5O
6Q
7R
MAGNETIC
GULFPORT CHANNEL
SAFETY FAIRWAY
Cable Area
Spoil Area
M I S S I S S
SCALE 1:40,000
NAUTICAL MILES
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YARDS
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	J	Small size, natural oyster beds and commercial oyster lease sites (Dotted stippling on maps with commercial sites shown by rectangular shapes).
	K	Openings to marinas and harbors.
4	L	Exposed, narrow bands of salt marsh subject to ordinary tidal inundation with elevated lands located behind them. In cases, a narrow sandy beach may occur between the bands of marsh and the elevated lands.
	M	Exposed, narrow sand beaches* with expansive salt marsh areas beginning immediately behind the beaches.
5	N	Exposed, wide sand beaches* with salt marshes located immediately behind the beaches.
	O	Exposed sand beaches* with elevated lands located behind the beaches.
	P	Inlets to areas with little or no marsh habitat.
6	Q	Long fishing piers on pilings.
7	R	Concrete seawalls and other solid bulkheads, and wharfs.

*Sediment analyses show sand beaches to be of a medium to fine texture.

Identification Symbols	Related Environmental Information
	Sand beach locations where shorebirds (e.g. terns, gulls, and skimmers) nest in concentrations and raise their young from April through August. Nesting sites are not subject to oil pollution under ordinary tidal conditions. Due to the "threatened" status of the least tern, primary nesting sites of this species are specifically identified on the maps.
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	Boat launching sites.

Legend II. Protection Priorities Under Unusually High Tidal Conditions

Identification Letters and Protection Priorities Under Ordinary Tidal Conditions (See descriptions in Legend I)	Shift in Protection Priorities [a]	New Protection Priorities Under Unusually High Tidal Conditions
3G	→	2
4M	→	2
5N	→	2

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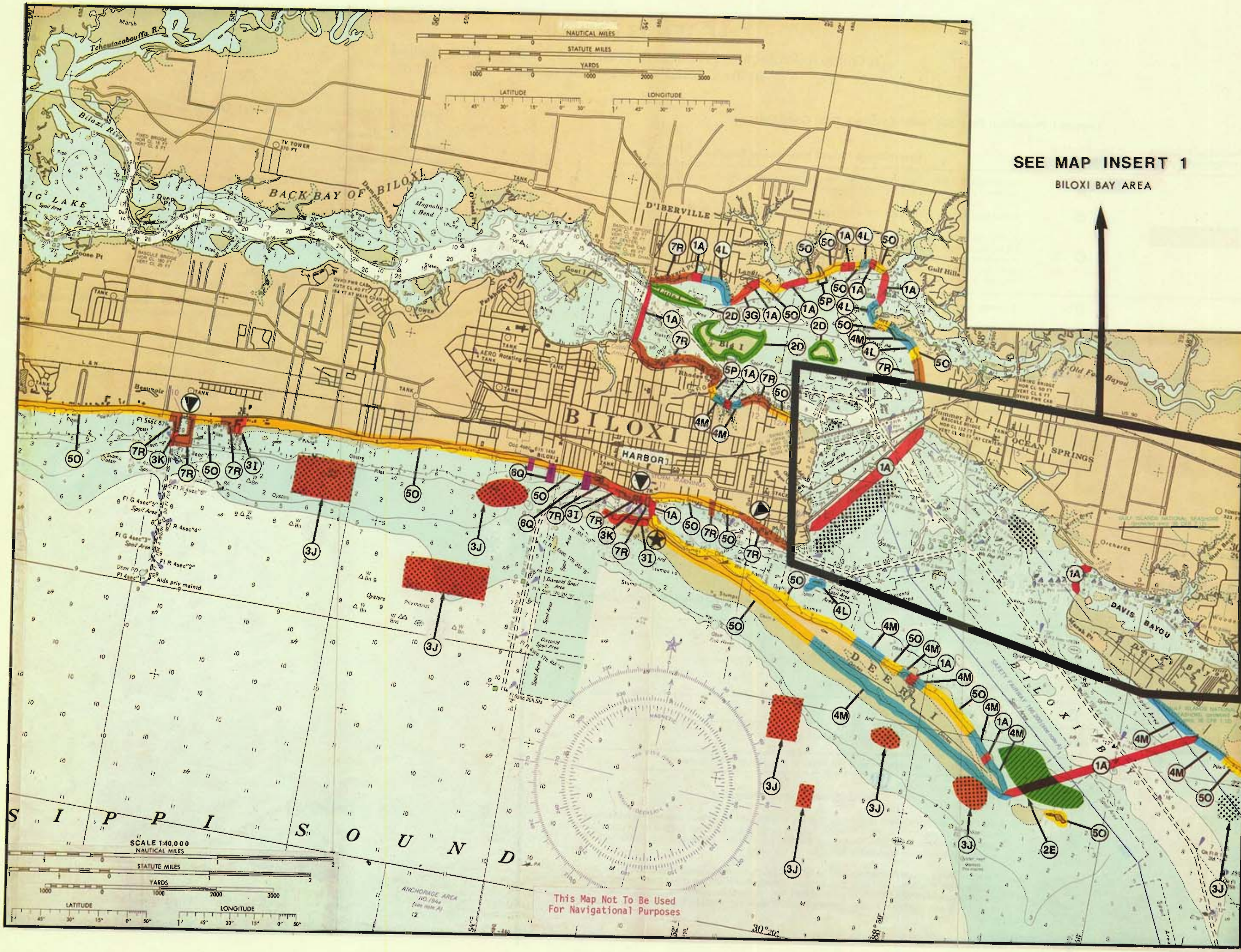
Protection Priorities shift when tidal waters are flooding or are expected to flood over the specified berms or sand beaches and when spilled oil is projected to move in the direction of salt marsh areas located behind the flooded berms or sand beaches.


SEE MAP INSERT 1
BILOXI BAY AREA
NAUTICAL MILES
STATUTE MILES
YARDS
LATITUDE
LONGITUDE
BACK BAY OF BILOXI
Biloxi River
D'IBERVILLE
BILOXI
HARBOR
OCEAN SPRINGS
DAVIS BAYOU
DEER ISLAND
BILOXI BAY
SIPPI SOUND
SCALE 1:40,000
This Map Not To Be Used
For Navigational Purposes

BASE MAP 4

LEGENDS I AND II

A Guide to Protection Priorities Applicable in the Event Oil is Spilled in the Coastal Waters of Mississippi

Legend I. Protection Priorities Under Ordinary Tidal Conditions

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2	D	Exposed, expansive salt marshes subject to ordinary tidal inundation.
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	Boat launching sites.

Legend II. Protection Priorities Under Unusually High Tidal Conditions

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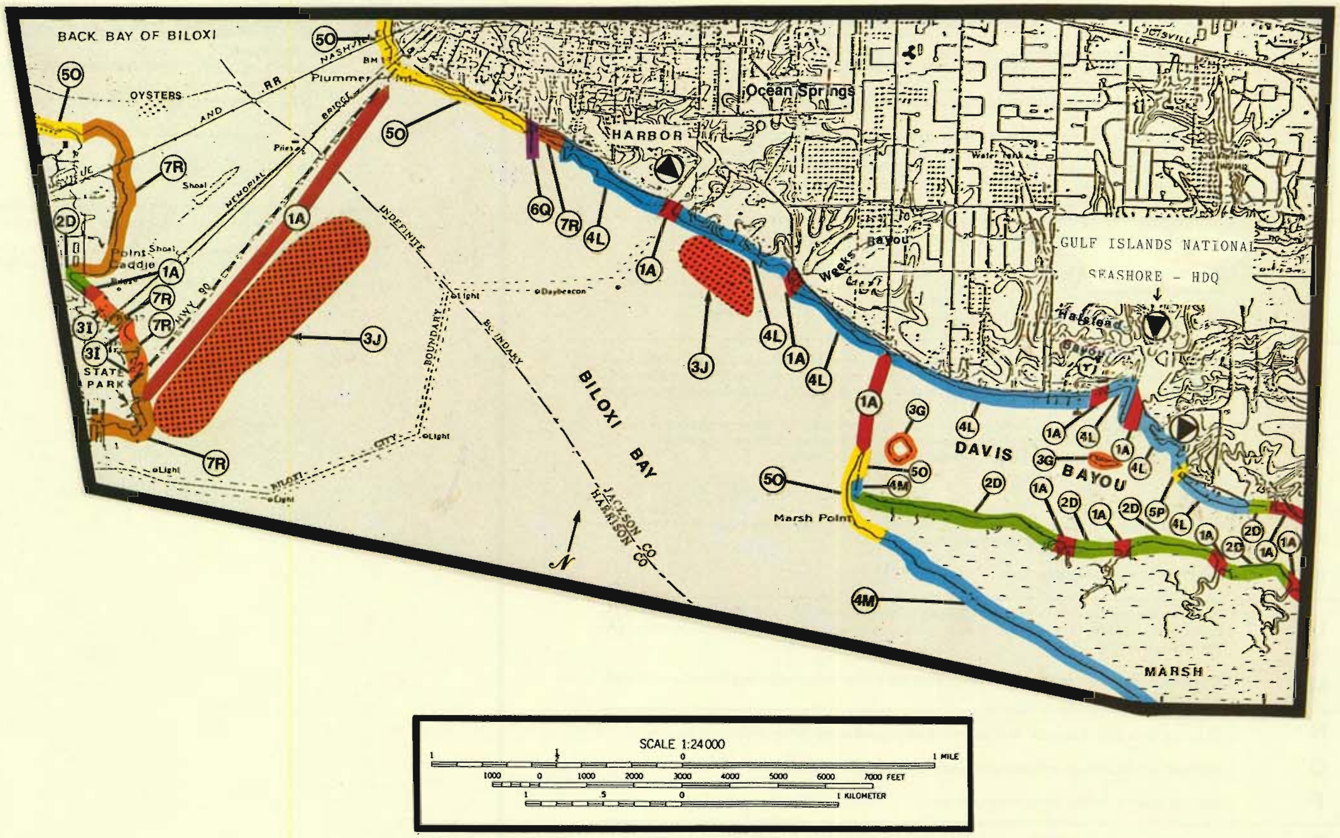

MAP
INSERT
1

MAP INSERT 1

BILOXI BAY AREA

LEGENDS I AND II

A Guide to Protection Priorities Applicable in the Event Oil is Spilled in the Coastal Waters of Mississippi

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Identification Symbols	Related Environmental Information
(star in circle)	Sand beach locations where shorebirds (e.g. terns, gulls, and skimmers) nest in concentrations and raise their young from April through August. Nesting sites are not subject to oil pollution under ordinary tidal conditions. Due to the "threatened" status of the least tern, primary nesting sites of this species are specifically identified on the maps.
(bird in circle)	Migratory waterfowl wintering habitat. The following expansive salt marsh areas serve as wintering sites (from November to April) for migratory waterfowl and are designated on the maps: (1) southernmost Hancock County (from the Pearl River to Point Clear, approx. 13,000 acres) and (2) southeastern Jackson County (from Point aux Chenes to the Middle Bay area, approx. 9,000 acres).
(triangle in circle)	Boat launching sites.

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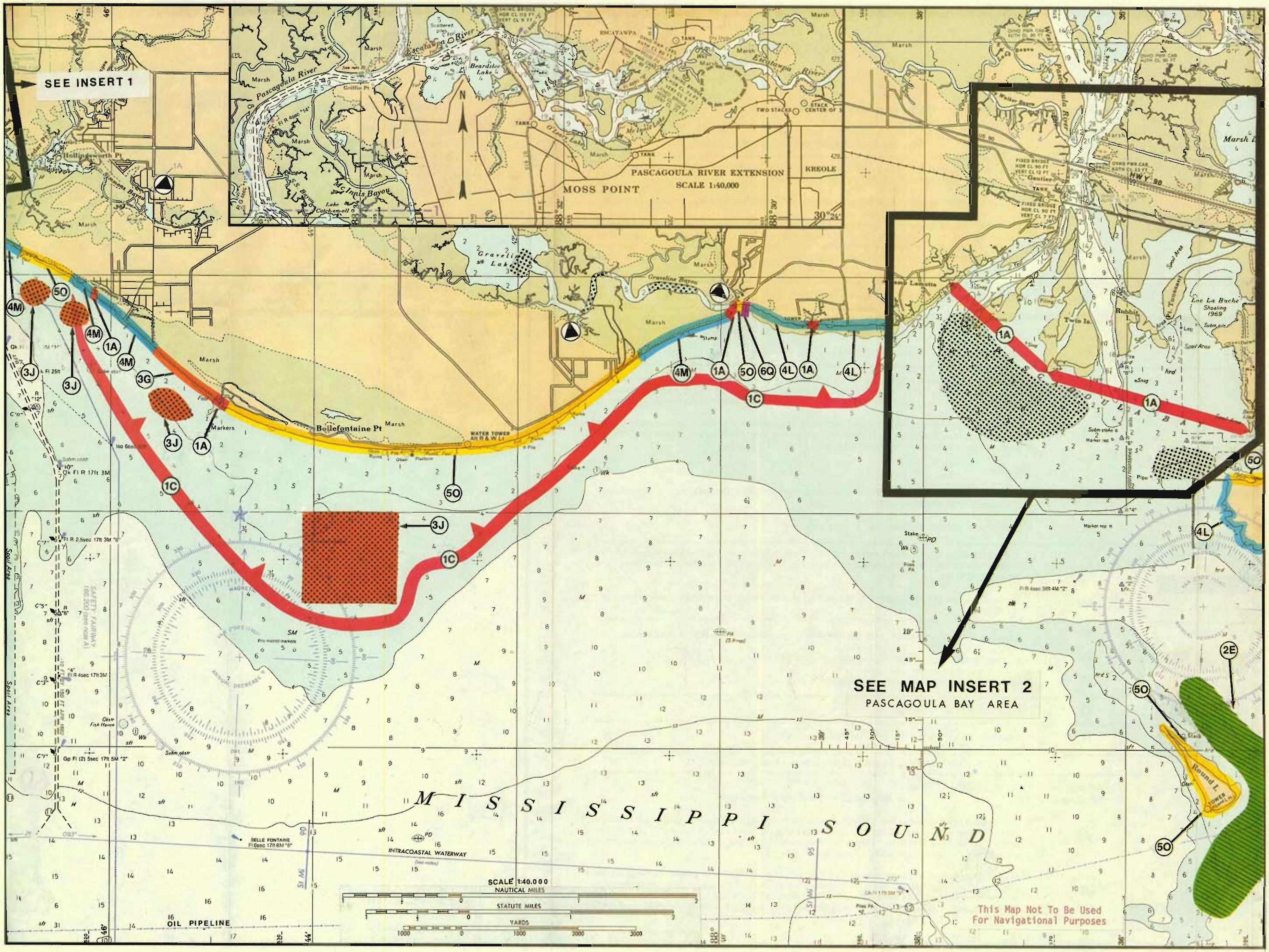
SEE INSERT 1
PASCAGOULA RIVER EXTENSION
SCALE 1:40,000
MOSS POINT
KREOLE
Pascagoula River
Escatawpa River
McInnis Bayou
Hollingsworth Pt
Bellefontaine Pt
Graveline Lake
Graveline Bayou
Marsh
WATER TOWER
HWY 90
Lea La Buche Shoaling 1969
SEE MAP INSERT 2
PASCAGOULA BAY AREA
MISSISSIPPI SOUND
INTRACOASTAL WATERWAY
OIL PIPELINE
Round I.
SCALE 1:40,000
NAUTICAL MILES
STATUTE MILES
YARDS
This Map Not To Be Used
For Navigational Purposes
4M
5O
3J
1A
3G
1C
6Q
4L
2E

BASE MAP 5

LEGENDS I AND II

A Guide to Protection Priorities Applicable in the Event Oil is Spilled in the Coastal Waters of Mississippi

Legend I. Protection Priorities Under Ordinary Tidal Conditions

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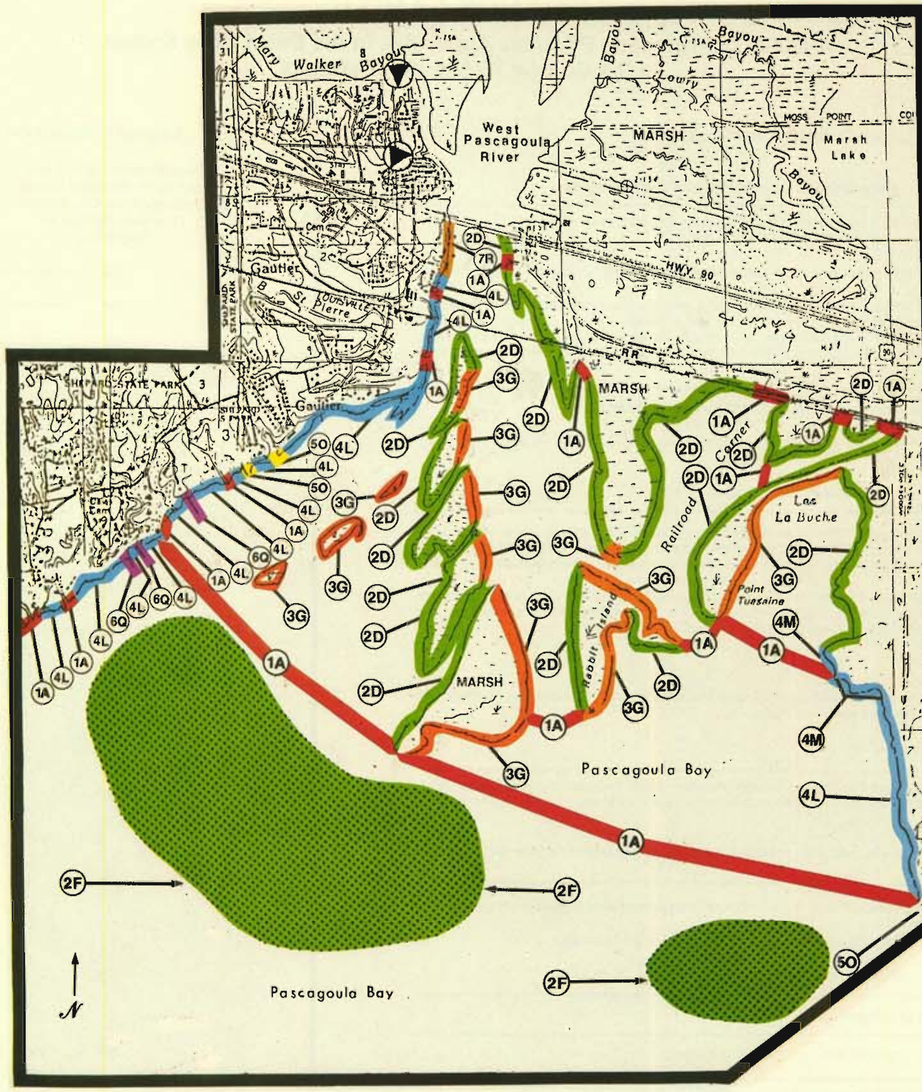

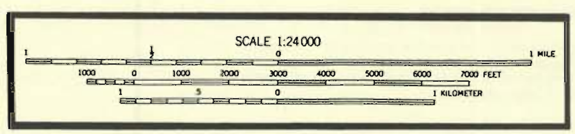

MAP INSERT 2

PASCAGOULA BAY AREA

MAP INSERT 2

LEGENDS I AND II

A Guide to Protection Priorities Applicable in the Event Oil is Spilled in the Coastal Waters of Mississippi

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(triangle symbol)	Boat launching sites.

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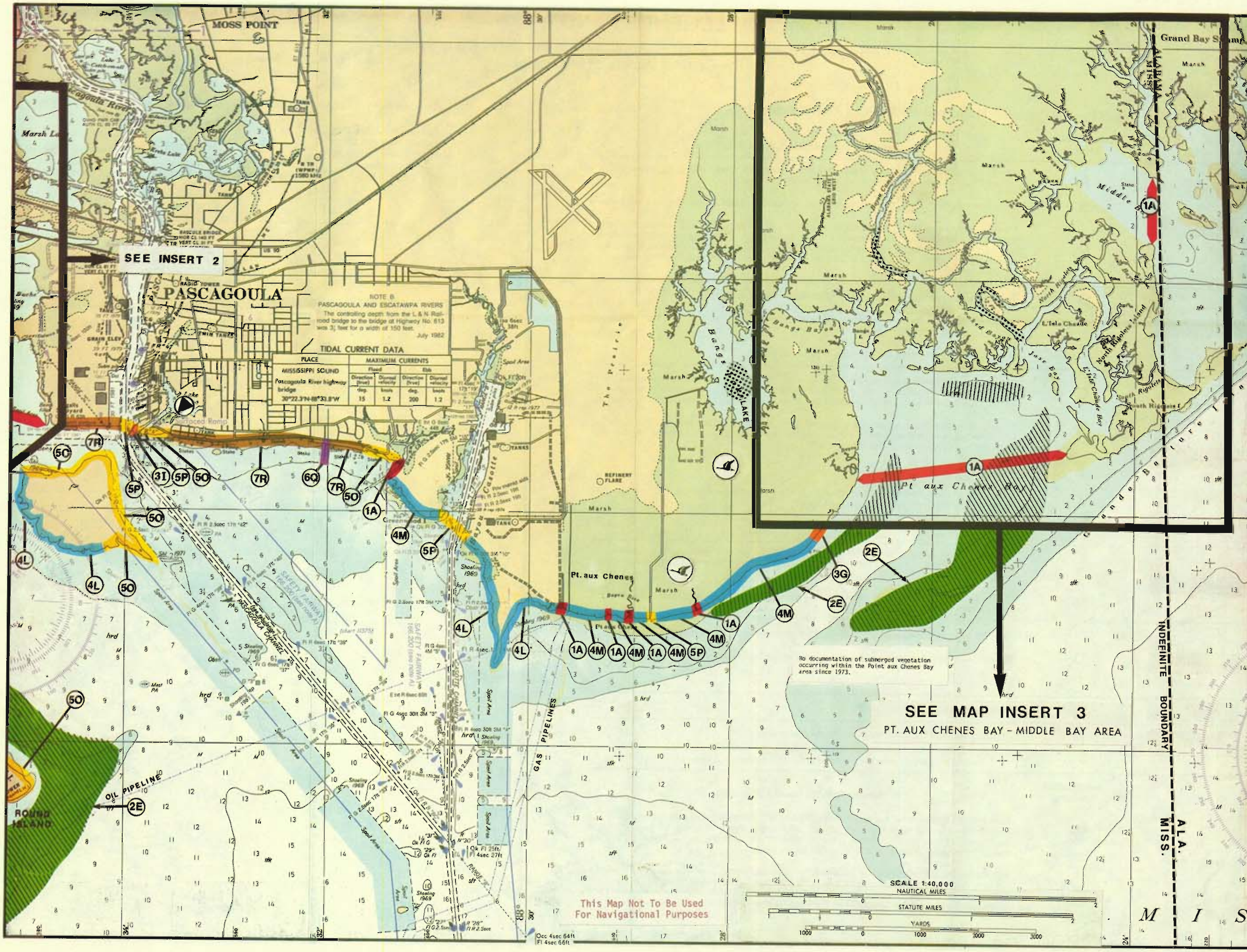

MOSS POINT
SEE INSERT 2
PASCAGOULA
TIDAL CURRENT DATA
Pt. aux Chenes
Marsh
Grand Bay Swamp
Middle Bay
Pt aux Chenes Bay
No documentation of submerged vegetation occurring within the Point aux Chenes Bay area since 1973.
SEE MAP INSERT 3
PT. AUX CHENES BAY - MIDDLE BAY AREA
GAS PIPELINES
OIL PIPELINE
ROUND ISLAND
INDEFINITE BOUNDARY
ALA.
MISS.
This Map Not To Be Used For Navigational Purposes
SCALE 1:40,000
NAUTICAL MILES
STATUTE MILES
YARDS

BASE MAP 6

LEGENDS I AND II

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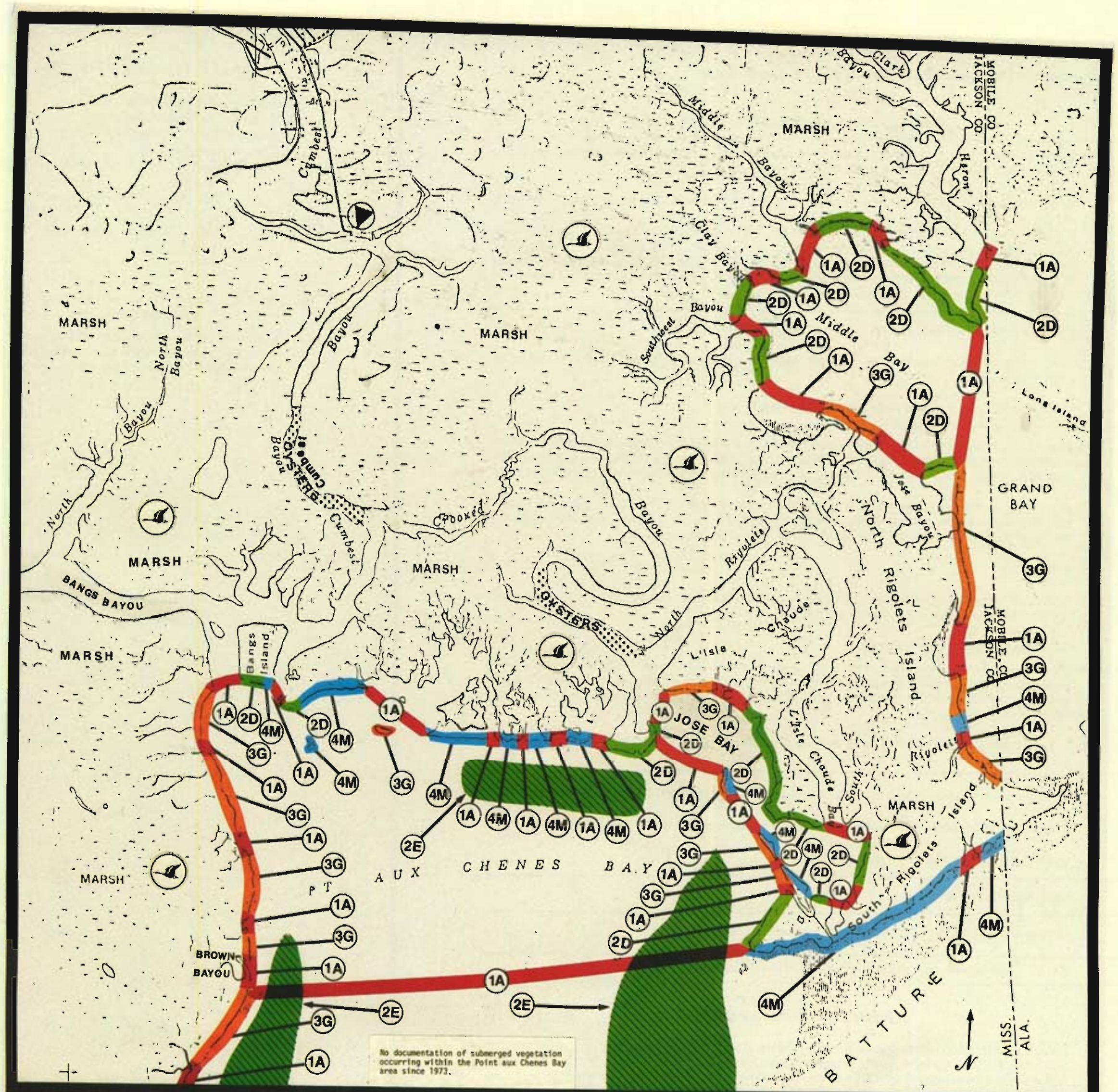

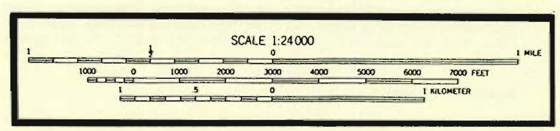

MAP INSERT 3

PT. AUX CHENES BAY- MIDDLE BAY AREA

MAP INSERT 3

LEGENDS I AND II

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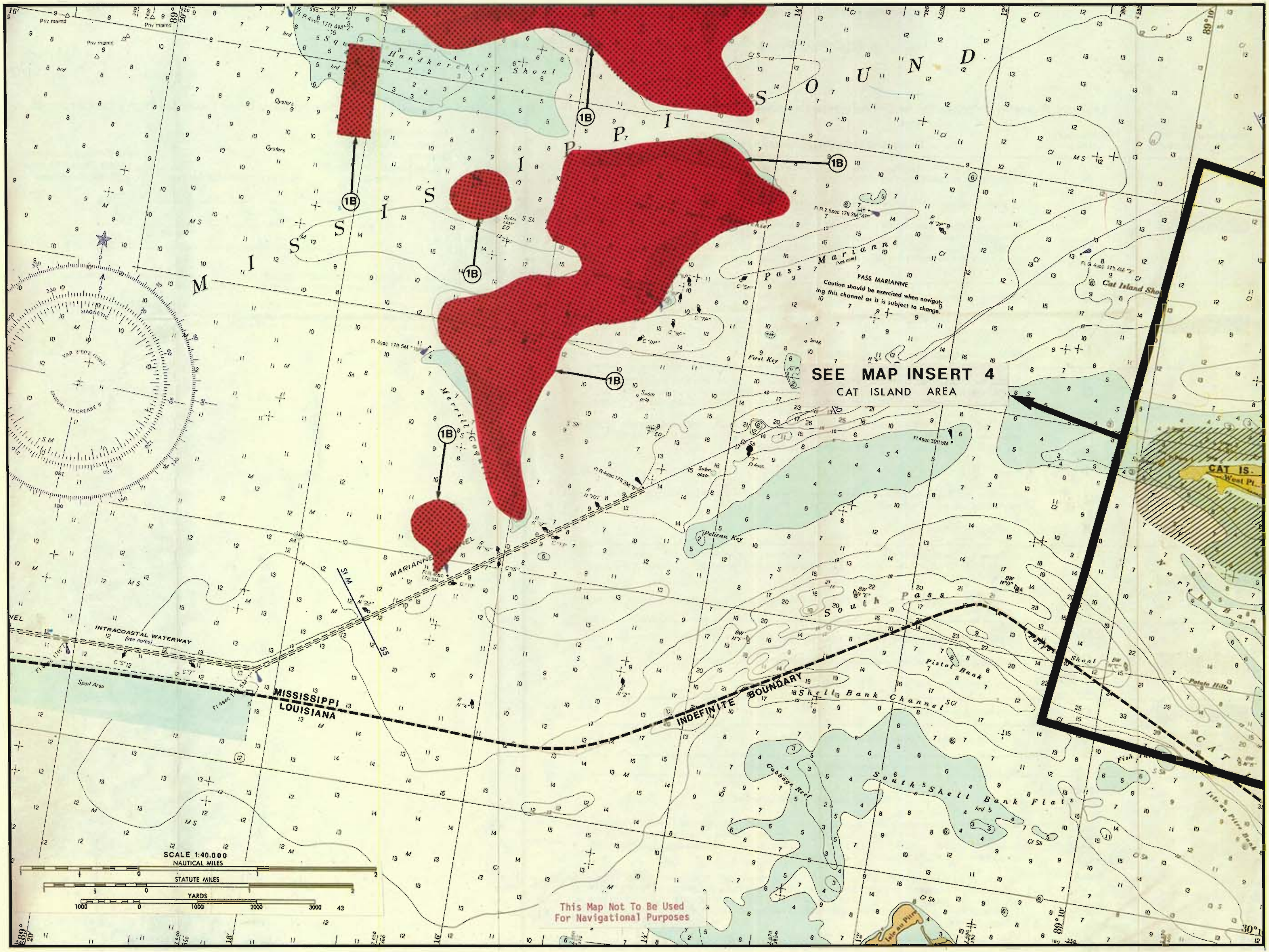
Protection Priorities shift when tidal waters are flooding or are expected to flood over the specified berms or sand beaches and when spilled oil is projected to move in the direction of salt marsh areas located behind the flooded berms or sand beaches.


MISSISSIPPI SOUND
Handkerchief Shoal
Oysters
PASS MARIANNE
Caution should be exercised when navigating this channel as it is subject to change.
Pass Marianne
First Key
SEE MAP INSERT 4
CAT ISLAND AREA
Cat Island Shoal
CAT IS.
West Pt.
Pelican Key
Merrill Coquille
MARIANNE CHANNEL
INTRACOASTAL WATERWAY
(see notes)
Spoil Area
MISSISSIPPI
LOUISIANA
INDEFINITE BOUNDARY
South Pass
Pistol Bank
Shell Bank Channel
Cabbage Reef
South Shell Bank Flats
Isle au Pitre
Isle au Pitre Bank
North Bank
Potato Hills
Fish
SCALE 1:40,000
NAUTICAL MILES
STATUTE MILES
YARDS
This Map Not To Be Used
For Navigational Purposes

BASE MAP 7

LEGENDS I AND II

A Guide to Protection Priorities Applicable in the Event Oil is Spilled in the Coastal Waters of Mississippi

Legend I. Protection Priorities Under Ordinary Tidal Conditions

Protection Priorities (1=highest priority)	Identification Letters	Description of Coastal Habitats and Structures
1	A	Barrier island passes; openings to rivers, bays, bayous and tidal creeks, all leading to exposed or sheltered salt marshes and very shallow estaurine waters.
	B	Large size, natural oyster beds and closely associated smaller beds (Dotted stippling on maps).
	C	A shallow, subtidal bottom that extends out to the 4-foot depth contour and attracts unusually high concentrations of early life stages of finfish and shellfish. (This exceptionally productive nursery ground is located off the Bellefontaine Point area, Jackson County.) This area also serves as an important wintering site (from November to April) for large numbers of various species of migratory ducks.
2	D	Exposed, expansive salt marshes subject to ordinary tidal inundation.
	E	Seagrass beds and attached macroscopic algal communities (Habitats shown on maps by parallel stippling).
	F	Medium size, natural oyster beds (Dotted stippling on maps).
3	G	Exposed, narrow bands of salt marsh subject to ordinary tidal inundation with a low, narrow berm located immediately behind the salt marsh and with an expansive marsh beginning immediately behind the berm. Also, exposed, moderate size salt marshes subject to ordinary tidal inundation.
	H	Sharply-rising shell beaches extending landward approximately 50 feet from the water's edge with an expansive marsh beginning immediately behind the shell beaches.(These beaches are restricted to an area south of Three Oaks Bayou, Hancock County.)
	I	Riprap.
	J	Small size, natural oyster beds and commercial oyster lease sites (Dotted stippling on maps with commercial sites shown by rectangular shapes).
	K	Openings to marinas and harbors.
4	L	Exposed, narrow bands of salt marsh subject to ordinary tidal inundation with elevated lands located behind them. In cases, a narrow sandy beach may occur between the bands of marsh and the elevated lands.
	M	Exposed, narrow sand beaches* with expansive salt marsh areas beginning immediately behind the beaches.
5	N	Exposed, wide sand beaches* with salt marshes located immediately behind the beaches.
	O	Exposed sand beaches* with elevated lands located behind the beaches.
	P	Inlets to areas with little or no marsh habitat.
6	Q	Long fishing piers on pilings.
7	R	Concrete seawalls and other solid bulkheads, and wharfs.

*Sediment analyses show sand beaches to be of a medium to fine texture.

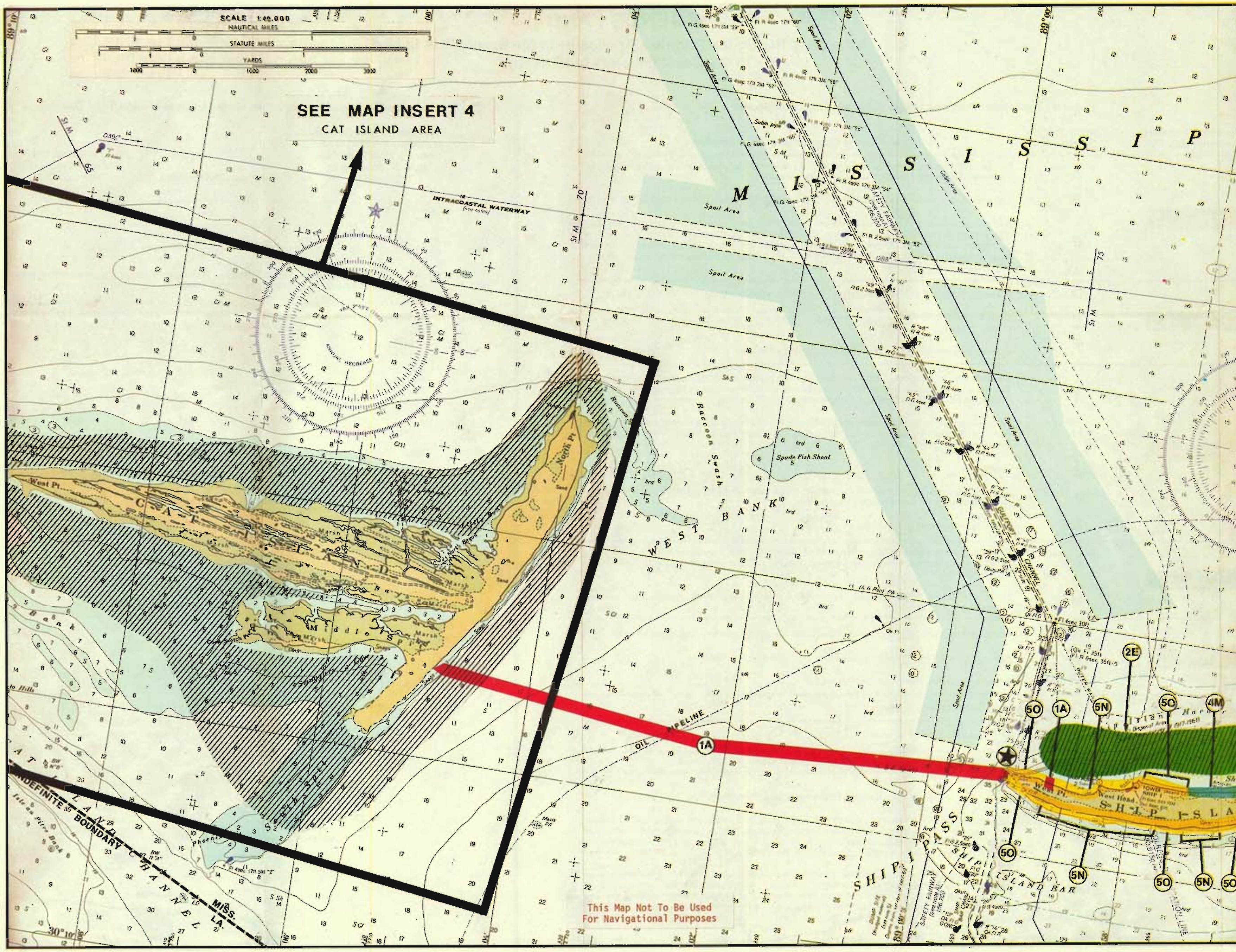
Identification Symbols	Related Environmental Information
	Sand beach locations where shorebirds (e.g. terns, gulls, and skimmers) nest in concentrations and raise their young from April through August. Nesting sites are not subject to oil pollution under ordinary tidal conditions. Due to the "threatened" status of the least tern, primary nesting sites of this species are specifically identified on the maps.
	Migratory waterfowl wintering habitat. The following expansive salt marsh areas serve as wintering sites (from November to April) for migratory waterfowl and are designated on the maps: (1) southernmost Hancock County (from the Pearl River to Point Clear, approx. 13,000 acres) and (2) southeastern Jackson County (from Point aux Chenes to the Middle Bay area, approx. 9,000 acres).
	Boat launching sites.

Legend II. Protection Priorities Under Unusually High Tidal Conditions

Identification Letters and Protection Priorities Under Ordinary Tidal Conditions (See descriptions in Legend I)	Shift in Protection Priorities[a]	New Protection Priorities Under Unusually High Tidal Conditions
3G	→	2
4M	→	2
5N	→	2

(a) Only the coastal habitats which shift in Protection Priorities are shown. Those not shown retain the Protection Priorities assigned under ordinary tidal conditions.

Protection Priorities shift when tidal waters are flooding or are expected to flood over the specified berms or sand beaches and when spilled oil is projected to move in the direction of salt marsh areas located behind the flooded berms or sand beaches.


SCALE 1:40,000
NAUTICAL MILES
STATUTE MILES
YARDS
SEE MAP INSERT 4
CAT ISLAND AREA
INTRACOASTAL WATERWAY
M I S S I S S I P
Spoil Area
Spade Fish Shoal
Raccoon Swash
WEST BANK
CAT ISLAND
West Pt.
North Pt.
Middle Spit
South Spit
OIL PIPELINE
1A
2E
5O
5N
4M
SHIP ISLAND
SHIP ISLAND PASS
SHIP ISLAND BAR
INDEFINITE BOUNDARY
CAT ISLAND CHANNEL
MISS.
LA.
This Map Not To Be Used
For Navigational Purposes

BASE
MAP
8

LEGENDS I AND II

A Guide to Protection Priorities Applicable in the Event Oil is Spilled in the Coastal Waters of Mississippi

Legend I. Protection Priorities Under Ordinary Tidal Conditions

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	B	Large size, natural oyster beds and closely associated smaller beds (Dotted stippling on maps).
	C	A shallow, subtidal bottom that extends out to the 4-foot depth contour and attracts unusually high concentrations of early life stages of finfish and shellfish. (This exceptionally productive nursery ground is located off the Bellefontaine Point area, Jackson County.) This area also serves as an important wintering site (from November to April) for large numbers of various species of migratory ducks.
2	D	Exposed, expansive salt marshes subject to ordinary tidal inundation.
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	H	Sharply-rising shell beaches extending landward approximately 50 feet from the water's edge with an expansive marsh beginning immediately behind the shell beaches.(These beaches are restricted to an area south of Three Oaks Bayou, Hancock County.)
	I	Riprap.
	J	Small size, natural oyster beds and commercial oyster lease sites (Dotted stippling on maps with commercial sites shown by rectangular shapes).
	K	Openings to marinas and harbors.
4	L	Exposed, narrow bands of salt marsh subject to ordinary tidal inundation with elevated lands located behind them. In cases, a narrow sandy beach may occur between the bands of marsh and the elevated lands.
	M	Exposed, narrow sand beaches* with expansive salt marsh areas beginning immediately behind the beaches.
5	N	Exposed, wide sand beaches* with salt marshes located immediately behind the beaches.
	O	Exposed sand beaches* with elevated lands located behind the beaches.
	P	Inlets to areas with little or no marsh habitat.
6	Q	Long fishing piers on pilings.
7	R	Concrete seawalls and other solid bulkheads, and wharfs.

*Sediment analyses show sand beaches to be of a medium to fine texture.

Identification Symbols	Related Environmental Information
	Sand beach locations where shorebirds (e.g. terns, gulls, and skimmers) nest in concentrations and raise their young from April through August. Nesting sites are not subject to oil pollution under ordinary tidal conditions. Due to the "threatened" status of the least tern, primary nesting sites of this species are specifically identified on the maps.
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	Boat launching sites.

Legend II. Protection Priorities Under Unusually High Tidal Conditions

Identification Letters and Protection Priorities Under Ordinary Tidal Conditions (See descriptions in Legend I)	Shift in Protection Priorities [(a)]	New Protection Priorities Under Unusually High Tidal Conditions
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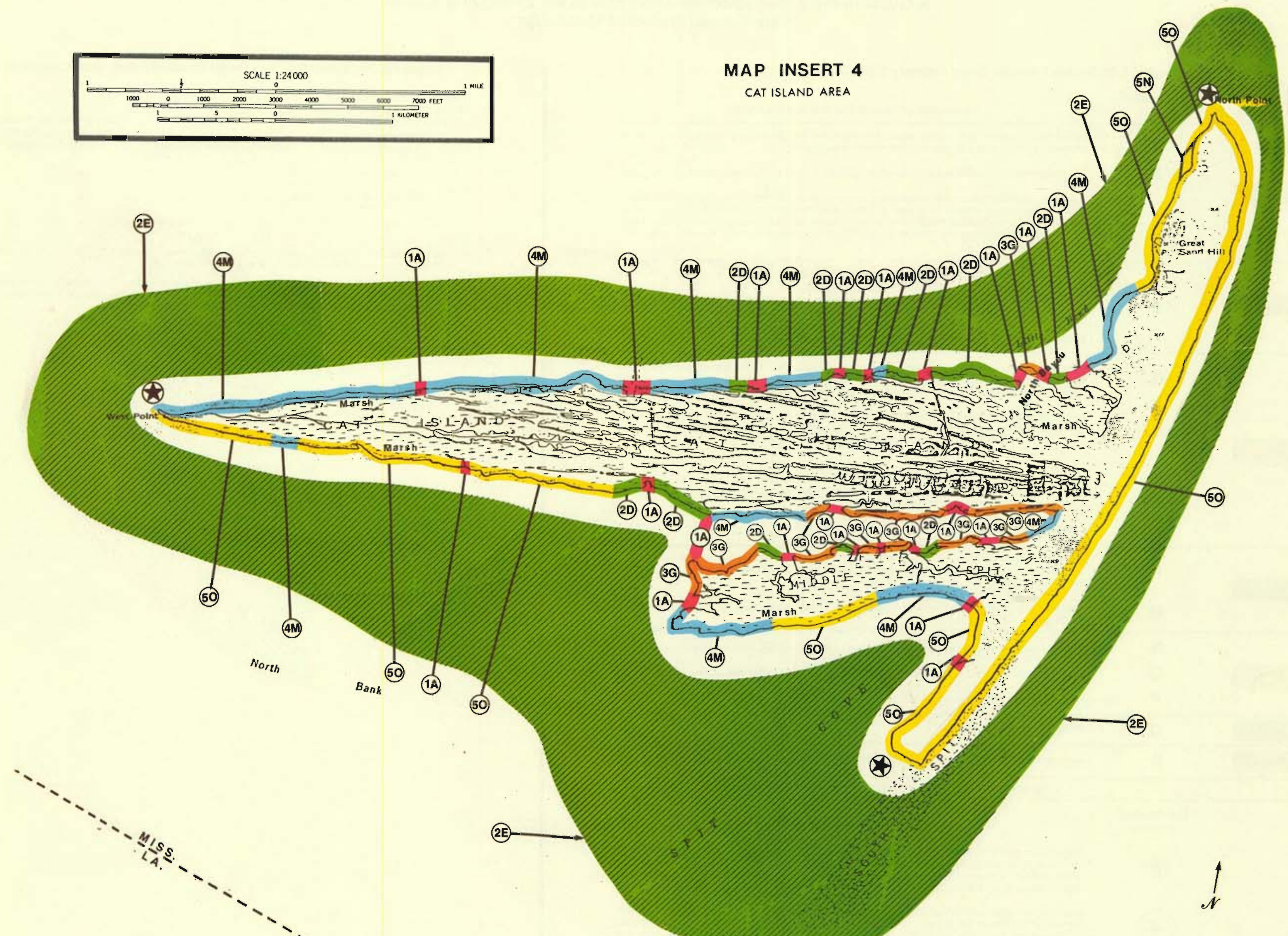

MAP INSERT 4
CAT ISLAND AREA
SCALE 1:24000
1 MILE
7000 FEET
1 KILOMETER
West Point
North Point
Great Sand Hill
CAT ISLAND
Marsh
MIDDLE SPIT
North Bank
COVE
SPIT
SOUTH SPIT
MISS.
LA.
2E
4M
1A
2D
3G
5O
5N

MAP INSERT 4

LEGENDS I AND II

A Guide to Protection Priorities Applicable in the Event Oil is Spilled in the Coastal Waters of Mississippi

Legend I. Protection Priorities Under Ordinary Tidal Conditions

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7	R	Concrete seawalls and other solid bulkheads, and wharfs.

*Sediment analyses show sand beaches to be of a medium to fine texture.

Identification Symbols	Related Environmental Information
(star symbol)	Sand beach locations where shorebirds (e.g. terns, gulls, and skimmers) nest in concentrations and raise their young from April through August. Nesting sites are not subject to oil pollution under ordinary tidal conditions. Due to the "threatened" status of the least tern, primary nesting sites of this species are specifically identified on the maps.
(waterfowl symbol)	Migratory waterfowl wintering habitat. The following expansive salt marsh areas serve as wintering sites (from November to April) for migratory waterfowl and are designated on the maps: (1) southernmost Hancock County (from the Pearl River to Point Clear, approx. 13,000 acres) and (2) southeastern Jackson County (from Point aux Chenes to the Middle Bay area, approx. 9,000 acres).
(triangle symbol)	Boat launching sites.

Legend II. Protection Priorities Under Unusually High Tidal Conditions

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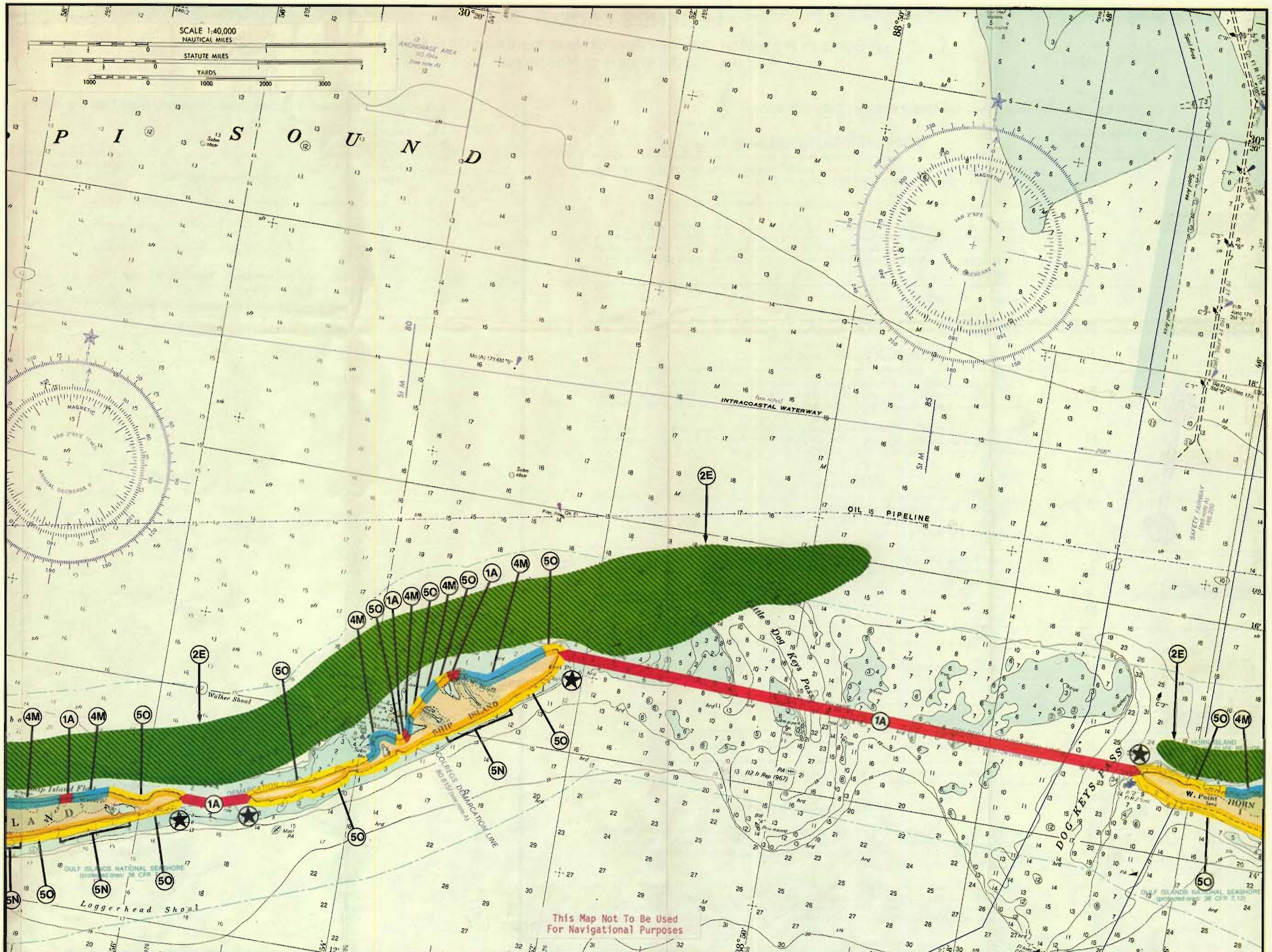
SCALE 1:40,000
NAUTICAL MILES
STATUTE MILES
YARDS
P I S S O U N D
MAGNETIC
ANNUAL DECREASE
INTRACOASTAL WATERWAY
OIL PIPELINE
Walker Shoal
SHIP ISLAND
DEMARCATION LINE
COLREGS DEMARCATION LINE
Dog Keys Pass
DOG KEYS PASS
W. Point
HORN
GULF ISLANDS NATIONAL SEASHORE
Loggerhead Shoal
SAFETY FAIRWAY
2E
4M
1A
5O
5N
This Map Not To Be Used
For Navigational Purposes

BASE MAP 9

LEGENDS I AND II

A Guide to Protection Priorities Applicable in the Event Oil is Spilled in the Coastal Waters of Mississippi

Legend I. Protection Priorities Under Ordinary Tidal Conditions

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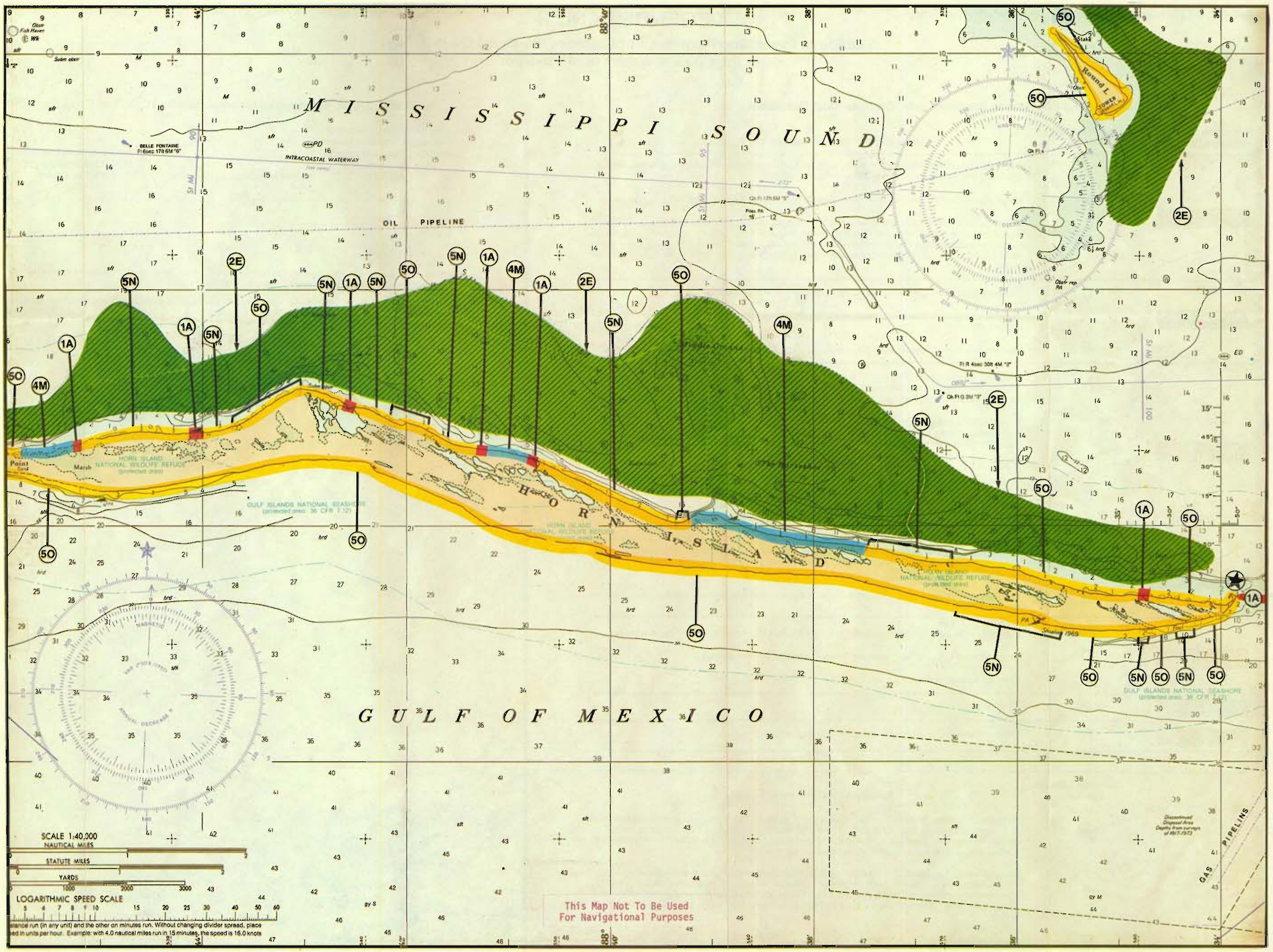
MISSISSIPPI SOUND
GULF OF MEXICO
HORN ISLAND
Round I.
OIL PIPELINE
INTRACOASTAL WATERWAY
HORN ISLAND NATIONAL WILDLIFE REFUGE (protected area)
GULF ISLANDS NATIONAL SEASHORE (protected area: 36 CFR 7.12)
GAS PIPELINES
SCALE 1:40,000
NAUTICAL MILES
STATUTE MILES
YARDS
LOGARITHMIC SPEED SCALE
This Map Not To Be Used
For Navigational Purposes
1A
2E
4M
5N
5O

BASE
MAP
10

LEGENDS I AND II

A Guide to Protection Priorities Applicable in the Event Oil is Spilled in the Coastal Waters of Mississippi

Legend I. Protection Priorities Under Ordinary Tidal Conditions

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Legend II. Protection Priorities Under Unusually High Tidal Conditions

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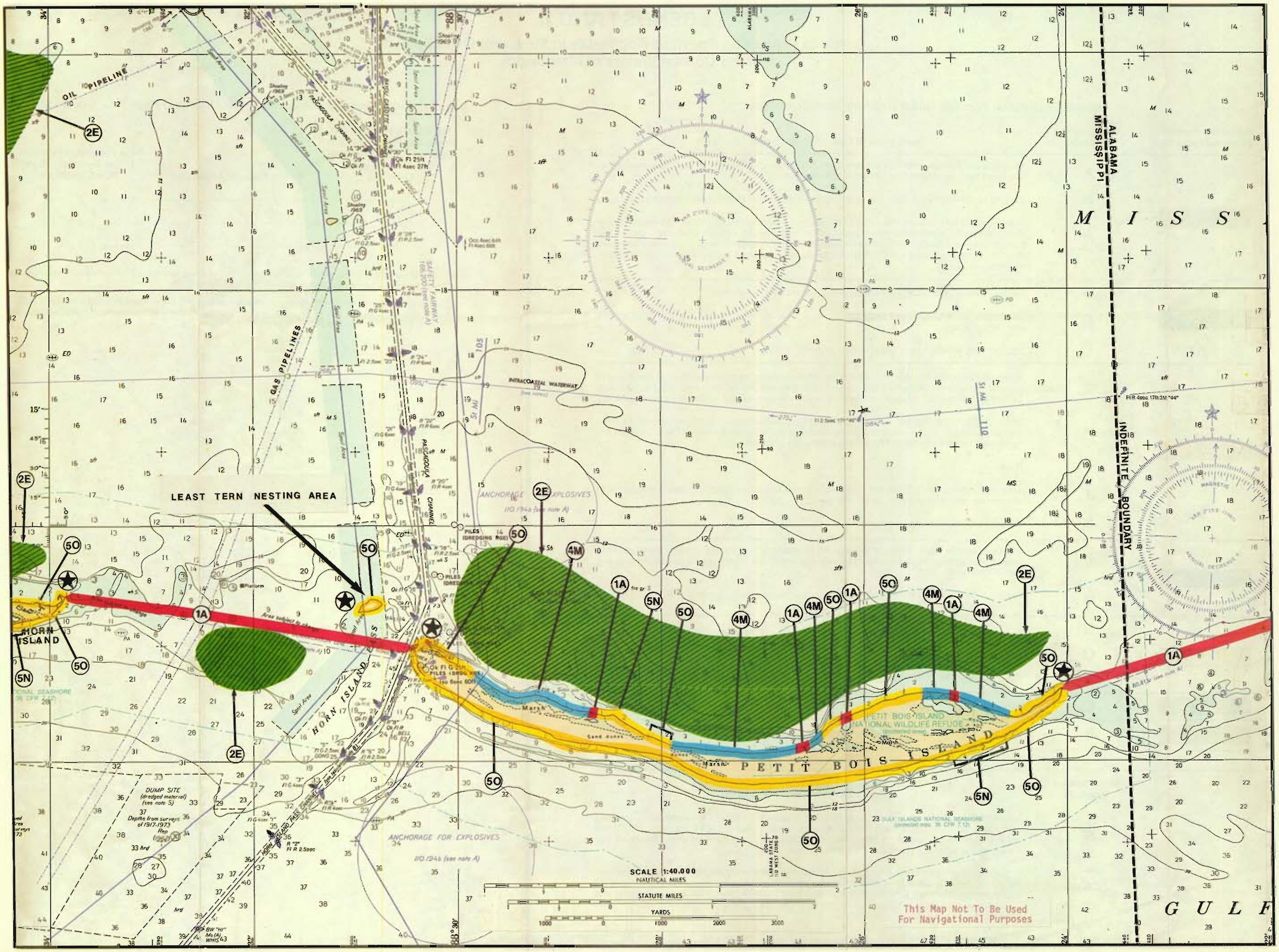
LEAST TERN NESTING AREA
OIL PIPELINE
GAS PIPELINES
HORN ISLAND
HORN ISLAND PASS
PASCAGOULA CHANNEL
PETIT BOIS ISLAND
PETIT BOIS ISLAND NATIONAL WILDLIFE REFUGE
INTRACOASTAL WATERWAY
ANCHORAGE FOR EXPLOSIVES
DUMP SITE (dredged material)
ALABAMA
MISSISSIPPI
INDEFINITE BOUNDARY
MISS
GULF
SCALE 1:40,000
NAUTICAL MILES
STATUTE MILES
YARDS
This Map Not To Be Used For Navigational Purposes
1A
2E
4M
5N
5O

BASE MAP 11

LEGENDS I AND II

A Guide to Protection Priorities Applicable in the Event Oil is Spilled in the Coastal Waters of Mississippi

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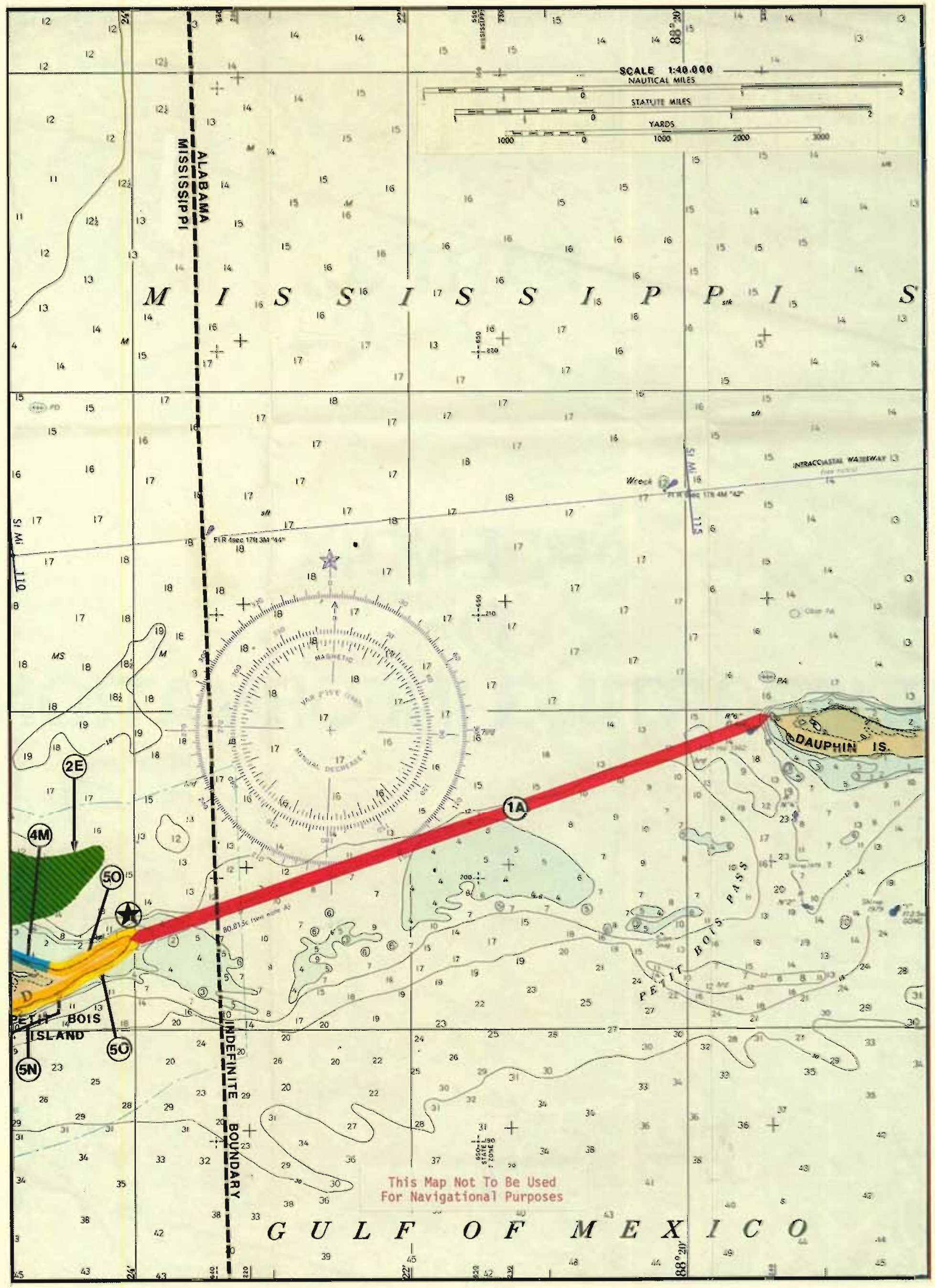
BASE MAP 12


SCALE 1:40,000
NAUTICAL MILES
STATUTE MILES
YARDS
ALABAMA
MISSISSIPPI
M I S S I S S I P P I S
INTRACOASTAL WATERWAY
Wreck
DAUPHIN IS.
PETIT BOIS ISLAND
P E T I T B O I S P A S S
INDEFINITE BOUNDARY
G U L F O F M E X I C O
This Map Not To Be Used
For Navigational Purposes
1A
2E
4M
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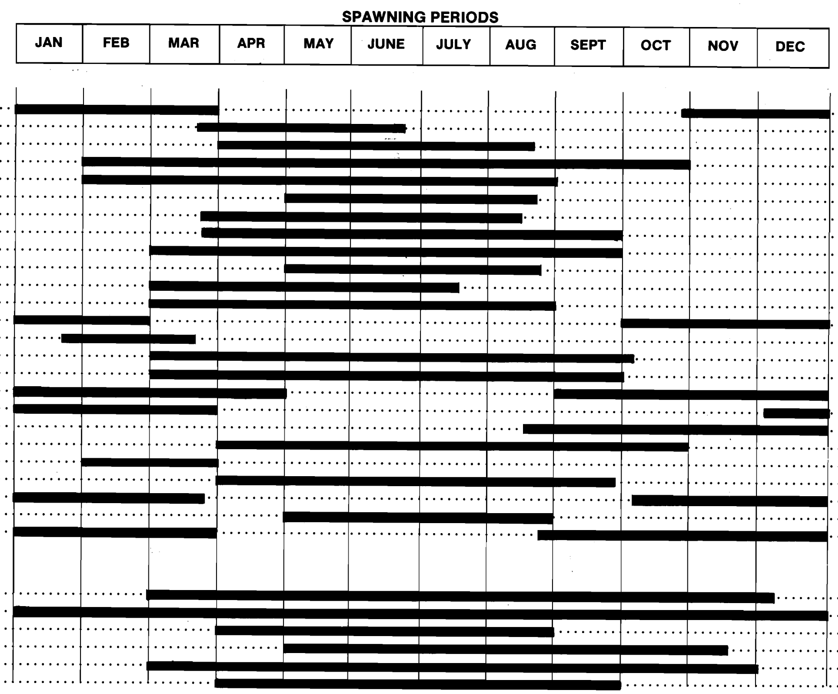
PART 3.

APPENDIX
OF
SUPPORTING INFORMATION

TABLE 3-1

Spawning periods of representative commercial and recreational finfish and shellfish and their spawning locations within the Mississippi Sound, adjacent waters and open Gulf of Mexico.[a]



SPECIES	SPAWNING LOCATIONS[b]
FINFISH SPECIES	
Brevoortia patronus (Gulf menhaden)	3,4
Alosa chrysochloris (Skipjack herring)	
Harengula jaguana (Scaled sardine)	4
Anchoa mitchilli (Bay anchovy)	3,4
Anchoa hepsetus (Striped anchovy)	4
Arius felis (Sea catfish)	1,2,3
Fundulus similis (Longnose killifish)	1,3
Fundulus grandis (Gulf killifish)	1,3
Membras martinica (Silverside)	3,4
Trachinotus carolinus (Pompano)	4
Caranx latus (Horse-eyed jack)	4
Caranx hippos (Jack crevalle)	4
Lagodon rhomboides (Pinfish)	4
Archosargus probatocephalus (Sheepshead)	4
Cynoscion nebulosus (Spotted seatrout)	2,3
Cynoscion arenarius (White seatrout)	3,4
Micropogonias undulatus (Atlantic croaker)	3,4
Leiostomus xanthurus (Spot)	4
Sciaenops ocellatus (Red drum)	3,4
Menticirrhus americanus (Southern kingfish)	2,3,4
Pogonias cromis (Black drum)	1,2,3,4
Larimus fasciatus (Banded drum)	4
Mugil cephalus (Striped mullet)	3,4
Scomberomorus maculatus (Spanish mackerel)	4
Paralichthys lethostigma (Southern flounder)	4
SHELLFISH SPECIES	
Crassostrea virginica (American oyster)	1,2
Penaeus aztecus (Brown shrimp)	4
Penaeus setiferus (White shrimp)	4
Penaeus duorarum (Pink shrimp)	4
Callinectes sapidus (Blue crab)	2,3,4
Menippe mercenaria (Stone crab)	4

(a) The species listed are important to the Mississippi fishery. Some species listed may not contribute directly to the commercial or recreational fishery but have been determined to either have fishery potential or represent an important food source for major fishery species. A similar table of information was originally prepared in 1978 by Frederick Deegen and Cornell M. Ladner. The content of the 1978 presentation has been modified and additional material included to provide the information presented in this table.

(b) Legend: Spawning locations as currently known:

1. Mainland nearshore estuarine waters and inlets
2. Open Mississippi Sound
3. Barrier island nearshore waters and island passes
4. Open Gulf of Mexico

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TABLE 3-2

Within general areas of Mississippi coastal waters, monthly occurrences of adults and early life-stages of finfish and shellfish representative of the Mississippi saltwater commercial or recreational fishery.

□ ■ OCCURRENCES

Species	Mississippi Sound and estuarine waters												Barrier island passes and nearshore barrier island Gulf waters											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
FINFISH SPECIES																								
Brevoortia patronus (Gulf menhaden)																								
Adult	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Early life stages	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			■	■	■
Anchoa mitchilli (Bay anchovy)[1]																								
Adult	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Early life stages				■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■
Anchoa hepsetus (Striped anchovy)[1]																								
Adult					□	□	□	□	□	□	□	□			□	□	□	□	□	□	□	□	□	
Early life stages					■	■	■	■	■	■	■				■	■	■	■	■	■	■	■	■	
Cynoscion nebulosus (Spotted seatrout)																								
Adult	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Early life stages			■	■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■
Cynoscion arenarius (Sand seatrout)																								
Adult					□	□	□	□	□	□	□	□		□	□	□	□	□	□	□	□	□	□	□
Early life stages					■	■	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■
Micropogonias undulatus (Atlantic croaker)																								
Adult			□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Early life stages	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Leiostomus xanthurus (Spot)																								
Adult	□								□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Early life stages	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Sciaenops ocellatus (Red drum)																								
Adult	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Early life stages	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Menticirrhus americanus (Southern kingfish)																								
Adult	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Early life stages					■	■	■	■	■	■	■	■				■	■	■	■	■	■	■		
Pogonias cromis (Black drum)																								
Adult	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Early life stages	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Mugil cephalus (Striped mullet)																								
Adult			□	□	□	□	□	□	□	□				□	□	□	□	□	□	□	□	□	□	
Early life stages	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Scomberomorus maculatus (Spanish mackerel)																								
Adult				□	□	□	□	□	□							□	□	□	□	□	□	□	□	
Early life stages					■	■	■	■	■						■	■	■	■	■	■	■			
Paralichthys lethostigma (Southern flounder)																								
Adult			□	□	□	□	□	□	□	□			□	□	□	□	□	□	□	□	□	□	□	□
Early life stages	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
SHELLFISH SPECIES																								
Crassostrea virginica (American oyster)[2]																								
Adult	□	□	□	□	□	□	□	□	□	□	□	□												
Early life stages				■	■	■	■	■	■	■	■	■				■	■	■	■	■	■	■		
Penaeus aztecus (Brown shrimp)																								
Subadult					□	□	□	□	□	□	□						□	□	□	□	□	□		
Early life stages		■	■	■	■	■	■	■	■	■	■			■	■	■	■	■	■	■	■	■	■	
Penaeus setiferus (White shrimp)																								
Adult	□	□	□	□	□			□	□	□	□	□	□	□	□	□	□				□	□	□	□
Early life stages					■	■	■	■	■	■						■	■	■	■	■	■	■		
Penaeus duorarum (Pink shrimp)																								
Subadult	□	□	□	□						□	□	□	□	□	□	□	□	□					□	□
Early life stages							■	■	■	■	■	■						■	■	■	■	■		
Callinectes sapidus (Blue crab)																								
Adult	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Early life stages	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Menippe mercenaria (Stone crab)																								
Adult	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□	□
Early life stages	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

[1]Not a commercial or recreational species but a key food source for certain economically valuable finfish.

[2]Small oyster beds occur within some of the lagoons which are associated with Mississippi's offshore barrier islands.

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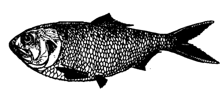
TABLE 3-3

Life History Highlights of Representative Finfish and Shellfish Which Occur in Mississippi Coastal Waters and are Important to the Mississippi Marine Fishery

Finfish

Gulf menhaden - Brevoortia patronus



Adults

- generally reach sexual maturity in the second year of life; live up to 4 years with majority of stocks comprised of 1-2 year old fish
- can tolerate wide range of temperature and salinity
- filter feeding, feed on phytoplankton, zooplankton, detritus and bacteria
- congregate near the mainland shoreline in the spring and summer in lower salinity waters (5-15 ppt)
- move offshore in the fall and winter to warmer, higher saline (greater than or equal to 30 ppt) waters
- spawning reported to occur from October through March in open Gulf waters usually less than 60 feet in depth, may spawn 4-5 times during this period, releasing only a fraction of mature ova and sperm each time; migrate back inshore after spawning

Eggs

- buoyant
- hatch within 48 hours
- require relatively high salinity water (at least 25-32 ppt) at a temperature range of 10-26° for survival

Larvae

- passively transported by water currents into estuarine areas during October through April
- lower salinities are thought to be required for development
- feed on pelagic zooplankton

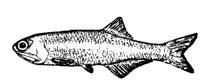
Juveniles

- tolerate a wide range of temperatures (5-34° C)
- first year juveniles inhabit shallow estuarine areas in waters of 5-10 pt salinity
- larger juveniles migrate to deeper, more saline bays and nearshore barrier island waters from May-July, where large schools are formed
- less than 3 ppm DO are fatal unless higher concentrations of DO are accessible by migration
- filter feeding; omnivorous feeding habits

Other Information

The gulf menhaden supports the largest commercial fishery by weight in Mississippi. In 1979 over 318,000,000 pounds of menhaden with a dockside value of approximately $13 million were landed in Mississippi. Preliminary 1982 figures indicate a 315,000,000 pound fishery valued at some $10 million.

Bay anchovy - Anchoa mitchilli



Adults

- approach sexual maturity within several months of hatching
- eurythermal; occur over the entire range of Mississippi coastal water temperatures
- euryhaline; abundant in local coastal waters with salinities greater than 2 ppt
- feed on copepods and mysid shrimp
- movement of fish 40 mm in standard length (adults approaching sexual maturity) and larger to nearshore barrier island waters prior to spawning; movement especially noticeable during January
- primarily spawn in offshore Gulf waters near barrier island passes from February through Ocober, peaking in July

Eggs

- pelagic; distributed throughout water column but most abundant near surface
- hatch within 24 hours

Larvae

- found most often near barrier islands from April through August, over a salinity range of 20.0-27.8 ppt

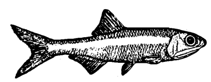
Juveniles

- individuals smaller than 40 mm (standard length) in size prefer mainland nearshore estuarine waters of Mississippi Sound and adjacent bays

Other Information

Local research indicates that during the greater part of the year the bay anchovy is the most abundant finfish species within Mississippi Sound and adjacent estuarine waters. This species currently represents an underutilized commercial resource. The bay anchovy is an important food item for many commercial finfish species. Knowledge of life history and habitat requirements is incomplete.

Striped anchovy - Anchoa hepsetus



Adults

- maturity reached within 7 to 8 months after hatching
- prefer temperatures from 10-35° C
- prefer higher saline Gulf waters near and beyond the barrier islands and occur there in great numbers
- generally do not occur in nearshore Mississippi Sound waters from January to the spring and are infrequent inhabitants of this area during the remainder of the year
- occasionally interact with inshore populations of the bay anchovy, Anchoa mitchilli, under higher saline conditions
- spawn in offshore Gulf waters from February through August

Eggs

- pelagic
- hatch near the surface
- highest concentrations occur February through May
- associated with higher salinities found in Gulf waters, nearshore barrier island waters and deeper bays and channels

Larvae

- larvae and postlarvae found from the spring to the fall
- larvae and postlarvae generally found in Mississippi Sound waters north of the barrier islands to the Intracoastal Waterway; uncommon north of the Intracoastal Waterway
- feed primarily on copepod nauplii

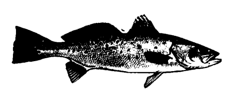
Juveniles

- occur in higher saline Mississippi Sound waters and nearshore island waters during the spring, summer and fall
- feed primarily on copepods

Other Information

This species is not as abundant in Mississippi coastal waters as the bay anchovy, Anchoa mitchilli. It serves as an important food source for numerous commercial and recreational finfish species. Information pertaining to life history and habitat requirements is incomplete.

Spotted seatrout - Cynoscion nebulosus



Adults

- adults occur throughout Mississippi Sound and nearshore island waters; mature between 1-3 years
- prefer a temperature range of 15-27° C
- euryhaline; appear to be most abundant between 20-35 ppt salinity
- prefer shallow areas 3 to 6 m in depth, especially near grassbeds and oyster reefs
- opportunistic carnivores, feed primarily on crustaceans and fish
- may overwinter in deeper bays or offshore deep water areas
- migrate in the spring to waters adjacent to barrier island northern shorelines and to mainland nearshore waters
- spawn from March-October; peak spawning occurring May-July near offshore barrier islands and adjacent seagrass flats at depths of 3-5m
- spawning occurs at temperatures of 20-30° C and salinities from 20 to 35 ppt

Eggs

- pelagic at salinities above 30 ppt and demersal below 25 ppt
- optimal survival temperature and salinity ranges of 20-30° C and 20-35 ppt, respectively

Larvae

- migrate and are transported by currents further into estuarine environment from May-October
- found among bottom vegetation or shell rubble in shallows

Subjuveniles

- occur principally among vegetated flats and seagrass beds
- feed on copepods and caridean shrimp

Juveniles

- during warm months prefer shallow areas and vegetated flats within Mississippi Sound and adjacent waters; tend to school and move to deeper, warmer waters near channels and island passes in winter months
- schooling continues into and throughout adulthood
- feeding preference for penaeid shrimp and small fishes

Other Information

The spotted seatrout or "speck" is one of the most sought-after marine game fish species in Mississippi coastal waters. Almost 0.5 million "specks" were landed by sport fishermen in 1979. The spotted seatrout is basically a non-migratory resident of Mississippi Sound and adjacent bays and bayous.

Sand seatrout - Cynoscion arenarius

Adults

- young adults occur throughout Mississippi coastal waters; thought to mature at 2 years at which time they move in numbers to nearshore island waters and then further offshore
- eurythermal; occur over a temperature range of 5-35° C
- euryhaline; occur over a salinity range of 0-35.5 ppt
- feed on fish and crustaceans
- spawn from March through September; spawning is thought to occur near island passes and offshore Gulf waters
- migrate further offshore during the winter

Eggs

- pelagic

Larvae

- feed on plankton

Postlarvae

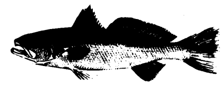
- immigrate to estuarine nursery grounds from April through early fall
- found over temperature and salinity ranges of 15-30° C and 0-30 ppt, respectively

Juveniles

- early juveniles abundant at salinities of less than 15 ppt, with the majority occurring below 10 ppt
- larger, more well-developed juveniles prefer waters greater than 15 ppt salinity
- greatest numbers occur in estuarine waters during the summer and fall at temperatures ranging from 25-30° C
- feed on a variety of benthic invertebrates and small fish

Other Information

The sand seatrout, also known as the "white trout," is a popular sport fish, as well as a component of the industrial bottomfish fishery.



Atlantic croaker - Micropogonias undulatus

Adults

- maturity reached at 1-2 years; few individuals remain in inside waters for more than 1 year
- eurythermal; occur within a wide range of temperatures; however, least cold-tolerant life cycle stage
- euryhaline; tolerate a wider range of salinities than the other life cycle stages
- school throughout life-span
- prefer mud bottom substrates throughout Mississippi Sound, nearshore island waters and offshore waters
- feed on a wide variety of invertebrates, fish and detritus
- spawning occurs in shallow open sea near island tidal passes and in wide areas of offshore continental shelf waters; spawning from September through April, peaking in November-December

Eggs

- pelagic
- hatch within one week

Larvae and Postlarvae

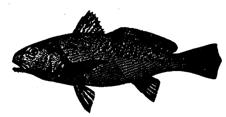
- migrate (passively and actively) into estuaries during the fall and winter
- live principally along the bottom
- primary food source consists of copepods

Juveniles

- tolerate a wide range of temperatures (6-32° C)
- early juveniles prefer salinities of 0.5-12 ppt, with older juveniles moving into more saline estuarine waters
- inhabit nearshore estuarine waters and marshes with tidal channels
- live primarily over muddy substrates high in organic content
- feed primarily on copepods, benthic invertebrates, small fish and detritus

Other Information

The atlantic croaker is a significant component of the industrial bottomfish, commercial food fish and recreational fisheries in Mississippi. In the mid-1970's croaker comprised 72% of the combined Mississippi-Louisiana industrial bottomfish fishery which during that period landed 52,600 tons with a processed value of $25 million dollars. Over 0.5 million juvenile and adult croaker were offloaded by commercial food fish vessels in Mississippi during 1982, with a dockside value of over $250,000. Over 1 million croaker, constituting 30% of the overall local recreational fishery, were landed by recreational fishermen in 1979.



Spot - Leiostomus xanthurus

Adults

- young adults occur throughout Mississippi coastal waters; mature at 2 years and then move offshore to deeper Gulf waters
- tolerate a wide range of temperatures and salinities
- feed on substrate to ingest benthic invertebrates, primarily polychaetes, ostracods and harpacticoid copepods
- spawn in nearshore continental shelf Gulf waters from December through March; it is generally believed that the majority of mature adults may spawn only once, this being as a Year Class-II fish; relatively few fish older than 2-3 years are found in local waters

Eggs

- transported into the nearshore island and estuarine waters during the winter and spring

Larvae - Postlarvae

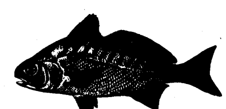
- migrate to estuary from December through April
- feed on microzooplankton; feed most actively in daylight

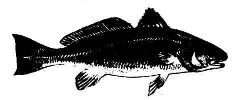
Juveniles

- are eurythermal and euryhaline
- develop in estuarine nursery grounds; concentrate in salt-marshes and edges of river channels near freshwater - salt-water interfaces
- prefer tidal creeks and seagrass beds near mud substrates
- prefer highly oxygenated water
- more abundant in shallow estuarine waters; higher concentrations locally at 4 m depths than at 8 m
- some segments of the juvenile population migrate to island passes and beyond to offshore waters in late fall and winter, with other members remaining in the estuarine environment during this time

Other Information

The spot comprises approximately 5-7% of the Mississippi-Louisiana industrial bottomfish fishery. There is no commercial food fishery for spot in Mississippi. It is taken often in the local recreational fishery.





Red drum - Sciaenops ocellatus

Adults

- mature at 2-4 years with males maturing more rapidly than females
- eurythermal, occur in Mississippi waters over a temperature range of 2-29° C
- euryhaline; occur at 0-40 ppt, with optimal salinities of 30-35 ppt
- in estuarine environment occur in greatest numbers during the spring and fall
- found over muddy, sandy or oyster reef substrates
- feed on crustaceans and fish
- mature adults school and return to open Gulf waters in late fall and winter
- spawn in schools near and in barrier island passes from late August to January; spawning peaking in late September through October

Eggs

- buoyant

Larvae

- enter estuarine waters from September-November
- found locally at temperatures between 20.5 - 31.0° C and salinities between 8.5 - 27.5 ppt
- more abundant near substrate than near the surface; seek quiet shallow waters near seagrass beds or muddy substrates

Postlarvae

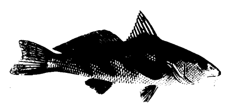
- migrate further into estuarine nursery areas and grow for 2 years
- feed primarily on copepods and copepod nauplii

Juveniles

- eurythermal and euryhaline, with optimal temperatures between 20-25° C and optimal salinities between 20-25 ppt
- reside in protected areas near fringes of marshlands
- feed on mysid shrimp, other invertebrates and small fish
- migrate to nearshore Gulf waters in cold weather and back to estuarine waters in early spring

Other Information

The red drum or "redfish" is both a coveted sportfish and a commercial foodfish. Commercial landings of redfish in Mississippi averaged over 94,000 pounds per year from 1979 to 1981.



Southern kingfish - Menticirrhus americanus

Adults

- mature at 1-3 years
- eurythermal; found locally within a temperature range of 8-37° C
- euryhaline; occur in local waters generally over a range of 5-35.5 ppt, with greater numbers present between 15-30 ppt
- reside in estuarine waters during the summer months
- migrate during the winter to the deeper inshore channels and to offshore Gulf waters
- feed on polychaetes, crustaceans and fish
- spawning may occur in both inshore waters and open Gulf from April through October, peaking in April

Eggs

- pelagic

Larvae

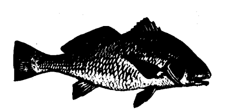
- immigrate to estuarine nursery grounds from April through November
- found in shallow waters near mainland and barrier island beaches
- eurythermal; found over a temperature range of 12-37° C
- euryhaline; found over a salinity range of 5-30 ppt

Juveniles

- small juveniles (less than 50 mm in standard length) reside in the open surf near sand beaches as well as in shallow waters above sand substrates grading to soft mud bottoms
- large juveniles (50-150 mm in standard length) are found in more open estuarine waters and passes between barrier islands
- feed on polychaetes, mysid shrimp and small fish

Other Information

The southern kingfish or "ground mullet" is an important commercial species as well as a conspicuous component of the local recreational fishery. An annual average of 263,000 pounds of kingfish were landed by commercial fishermen in Mississippi between 1964 and 1978.



Black drum - Pogonias cromis

Adults

- reach sexual maturity after 2 years of life
- inhabit shallow coastal estuarine waters; migration limited when food is plentiful within a given area
- eurythermal; tolerate 3-35° C, most abundant locally between 12-30° C
- can quickly adapt to a wide range of salinities (0-greater than 40 ppt); usually found in Mississippi waters at salinities of 9-26 ppt, with very large fish often found at higher salinities
- primarily bottom feeders, consuming molluscs (predator of oysters, especially transplanted oysters) and crabs; will also feed on small fish near surface
- solitary except for schooling during spawning season
- spawning in Mississippi waters occurs from February through March; spawning grounds may include bays, island passes and Gulf waters near barrier islands

Eggs

- pelagic
- hatch within 24 hours at 20° C

Larvae

- transported by tidal currents into Mississippi estuarine waters during the spring; peak transport appears to occur in March
- feed largely on zooplankton

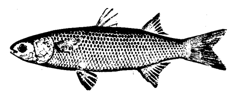
Juveniles

- tolerate extremes of temperature and salinity
- spend early juvenile stage in shallow, somewhat turbid waters
- move to deeper bays and coastal waters at sizes above 4 inches (greater than 100 mm) in length
- feed on marine annelids, molluscs, soft crustaceans and small fish

Other Information

Black drum commercial fishery landings in Mississippi averaged some 2.7 million pounds per year from 1979-1981. The average dockside value exceeded $276,000 per annum. This species is also considered to be one of the most important finfish in the winter recreational fishery of Biloxi Bay.

Striped mullet - Mugil cephalus



Adults

- mature at approximately 2 years of life
- occur at a wide range of temperatures
- euryhaline; tolerate 0-75 ppt salinity; occur in Mississippi waters from 0-36.0 ppt
- feed on epiphytic algae, diatoms and organic detritus
- reside in estuarine environment during all seasons with limited migration during this time
- form large schools and migrate offshore to spawn; spawning occurs from October to mid-March, peaking in late November through December
- early spawns occur near barrier islands; late spawns occur up to 40-50 miles offshore as water temperature drops

Eggs

- buoyant in higher salinity waters; may sink at low salinities

Larvae

- stage lasts 20-24 days
- planktonic; can be transported long distances by water currents

Postlarvae

- enter inshore nursery grounds from November-March
- travel in small schools near mainland shore
- greatest abundance in Mississippi waters at temperature and salinity ranges of 8-12.9° C and 0-14.9 ppt

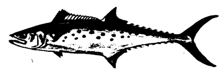
Juveniles

- remain in inshore nursery areas for 2 years
- small juveniles (30-80 mm in standard length) prefer salinity and temperature ranges of 0-10 ppt and 25-30° C, respectively
- intermediate juveniles (80-110 mm standard length) appear to be most abundant over a temperature range of 7-20° C and a salinity range of 0-20.0 ppt

Other Information

Striped mullet constitute a significant segment of the local commercial finfish fishery. An average of 1.6 million pounds of mullet were landed annually between 1979 and 1981 by Mississippi commercial fishermen, with annual dockside values averaging $282,000. Approximately one-quarter million striped mullet, representing some 7% of the sport fishery, were netted by sportsfishermen in 1979.

Spanish mackerel - Scomberomorus maculatus



Adults

- mature within 1-2 years; live up to 8 years
- adults usually occur in waters 21-26.7° C; seldom found below 18° C
- prefer salinities greater than 20 ppt
- feed primarily on small fish; may ingest crustaceans and molluscs
- large, dense schools are found near barrier islands and offshore Gulf waters, often near the surface
- indications of southerly fall migrations and northerly spring migrations within the Gulf; individuals inhabit nearshore barrier island waters from the spring through the fall
- nocturnal spawning occurs offshore from May to September at water temperatures above 22° C and at salinities ranging from 28-38 ppt

Eggs

- pelagic; hatch within 24 hours

Larvae

- approximately 2.3 mm long at hatching
- most abundant over shallow continental shelf waters at depths of 12-34 m

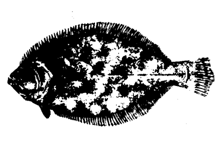
Juveniles

- prefer lower salinity Gulf waters near a clean sand bottom
- large schools occasionally sighted in Mississippi Sound and adjacent bays in the spring and summer
- reported to occur in Mississippi Sound over temperature and salinity ranges of 25-30° C and 5-30 ppt, respectively

Other Information

The spanish mackerel is a migratory pelagic species exhibiting an extensive alongshore movement throughout the northern Gulf of Mexico. An average of 47,000 pounds of spanish mackerel were landed by commercial fishermen in Mississippi during the years 1979-1981. This species is also an extremely popular sportfish, particularly during the summer and fall. Spanish mackerel may freely enter estuaries, however, the species is not estuarine-dependent.

Southern flounder - Paralichthys lethostigma



Adults

- begin to mature at approximately 230 mm standard length; are mature by 340 mm; growth rates per year have not been completely determined; females believed to mature at 4 or 5 years
- eurythermal and euryhaline; found between 5-35° C and 0-30 ppt in Mississippi Sound
- occur in estuarine waters in greater numbers during warmer months
- most abundant over mud and mud/sand bottoms
- feed primarily on shrimp and small fish
- spawn in offshore Gulf waters from September to April, spawning peaks in the late fall through early winter (November-January)

Eggs

- believed to be pelagic

Larvae

- move to inshore nursery areas from December through May; peak occurrence in February
- feed on plankton

Juveniles

- remain in estuarine nursery areas where their growth continues
- prefer vegetated, low to moderate saline waters; most abundant at 15-20 ppt
- early juveniles are planktonic feeders
- late juveniles feed more on crustaceans and small fish

Other Information

Flounder are a highly prized food fish. The combined weights of all commercially important flounder species landed by Mississippi commercial fishermen from 1979 to 1981 exceeded 41,000 pounds per annum. Recreational fishermen harvest many more flounder. The southern flounder is the most common large flounder caught in Mississippi waters.

Shellfish

American oyster - Crassostrea virginica

Adults

- can withstand wide range of temperatures
- euryhaline; normal salinity range of 5-35 ppt in Mississippi, optimal range 10-20 ppt
- require firm, stable substrate consisting of shell materials or mud/sand/shell mixtures firm enough to provide support
- filter-feeding; food items include diatoms, flagellates, bacteria and detritus
- moderate water currents needed to supply food, remove wastes and transport gametes
- spawning occurs March through November with peaks in June and September
- mature oysters spawn numerous times during spawning season; spawning is synchronous, with large numbers of oysters releasing gametes into the water column

Eggs

- sink to bottom and transported by currents; egg stage lasts 5-9 hours

Larvae

- normally free-swimming for an approximate "2-week" period
- require waterborne food particles; primarily planktivorous
- migrate vertically in water column to access acceptable salinity waters
- tolerance to salinity increased in larvae produced by oysters from high salinity waters
- following the "2-week" free-swimming stage, larvae prefer to settle and attach to clean cultch (shell, etc.) materials; large groups settle in a common area

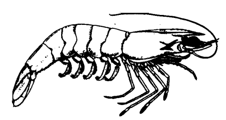
Juveniles

- upon settlement, mature to adult stage within 12 weeks during the summer and fall

Other Information

Approximately 5,000 acres of oyster bottoms are located in Mississippi coastal waters. During the 1981-82 oyster season some 170,000 sacks of oysters were harvested and landed in Mississippi at a dockside value of $1.4 million. Landings during the 1982-83 season increased dramatically to over 365,500 sacks, bringing a dockside value in excess of $2.7 million. Generally, 8.5 pounds of oyster meat are produced from each sack of oysters. In recent years the State has initiated efforts to revitalize the oyster industry through intensive shell plantings over state-managed reefs and by relaying several thousand barrels of seed oysters from closed harvest areas to approved growing areas.

Brown shrimp - Penaeus aztecus



Adults

- maturity reached in offshore Gulf waters within first year of life
- prefer salinities above 20 ppt
- highest densities found in offshore waters at depths between 27 m and 55 m
- favor mud and silt bottoms and to a lesser extent mud/shell/sand substrates
- omnivorous feeding habits, becoming more predatory at larger sizes (greater than 65 mm in length); major food items include polychaetes, amphipods and nematodes
- spawning is continuous within the Gulf population as a whole, with peaks in October through December and March through May; the majority of individuals are believed to spawn only once and then die, although some live to exceed 2.5 years
- spawn offshore at depths greater than 14 m, with the greatest percentage of ripe females found at depths near 45 m

Eggs

- demersal

Larvae

- develop in offshore Gulf waters; feed on plankton and suspended detritus

Postlarvae

- migrations inshore to estuarine nursery grounds from January through November; peak migration from February through May
- believed to move into estuaries primarily at night on incoming tide
- most abundant between temperatures of 15-35° C
- prefer salinities above 10 ppt
- prefer soft mud substrates within the shallow estuarine environment
- feed on detritus and scavenge among bottom sediments

Juveniles

- as growth continues seek mixed mud/sand bottoms as well as vegetated areas such as seagrass beds
- omnivorous feeding habits, fecal pellets are an important food item

Subadults

- occur throughout Mississippi Sound during the spring, summer and early fall months, with massive migrations occurring to and through island passes and into open Gulf waters at this time.

Other Information

The brown shrimp is by far the major shrimp species in Mississippi's commercial shrimping industry. For example, from 1979 to 1982 brown shrimp constituted 81% of the Mississippi shrimp harvest. In 1982 8,309,777 pounds (heads-on) of brown shrimp with a dockside value of $18,891,044 were landed in Mississippi. A bait shrimp industry utilizing juvenile and subadult brown shrimp thrives on the Mississippi coast. This species is a food source for numerous fishes and is an important component of the estuarine-marine food web.

White shrimp - Penaeus setiferus

Adults

- maturity generally reached during first year in offshore waters
- eurythermal; found in local waters between 4-31° C
- euryhaline; found in local waters between 1-40 ppt salinity
- rarely found offshore beyond barrier islands at depths exceeding 35 m; highest densities at depths of 18 m or less
- prefer mud and silt substrates, and to a lesser extent mud-shell and sand substrates
- omnivorous feeding habits, becoming more predatory at larger sizes (greater than 65 mm in length)
- spawn during warmer months (April through August) in Gulf waters at depths of 8-31m and at temperatures between 21-30° C

Eggs

- demersal

Larvae

- develop in offshore Gulf waters
- feed on plankton and suspended detritus

Postlarvae

- primary migration into local estuarine waters during June-September
- migrate further into low saline estuarine waters than do brown shrimp; prefer salinities of 10.0 ppt or less
- feed on detritus and scavenge on bottom sediments

Juveniles

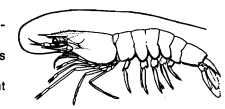
- prefer areas having silt and mud bottoms with patchy vegetation
- peak abundances in shallow marshes occur 1 to 2 months after peak postlarvae immigrations
- omnivorous feeding habits, fecal pellets are an important food item

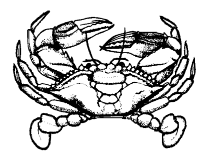
Subadults

- migrate from estuarine environment to island passes and open Gulf waters during the summer and fall
- local research has shown that subadults migrating from estuarine waters through the island passes to open Gulf waters during late fall may overwinter in shallow Gulf waters as sexually immature young adults. These young may then re-enter the estuarine environment during April and May at which time they reach sexual maturity and again migrate to Gulf waters where, as adults, they spawn.

Other Information

White shrimp comprised 15% of Mississippi's commercial shrimp landings from 1979-1982. In 1982 over 1,450,000 pounds (heads-on) of white shrimp with a dockside value exceeding $4.1 million were landed in Mississippi. The white shrimp also is harvested for the bait market.





Blue crab - Callinectes sapidus

Adults

- maturity reached in 1-1½ years of life
- omnivorous, with molluscs being dominant food organisms
- mate throughout Mississippi Sound and nearshore low salinity estuarine waters from March through November
- spring and summer mated females spawn within 2 months after mating
- fall mated females usually don't spawn until the water temperature rises in the spring
- females move to higher salinity waters near barrier islands when eggs are near hatching
- general movement from offshore to nearshore island waters with warming temperatures in the spring

Eggs

- carried by female (sponge crab)
- hatching occurs between 19-29° C, possibly up to 32° C
- optimal salinities for hatching between 23.0 and 30.0

Larvae

- zoeae develop offshore and can travel considerable distances via currents
- zoeae occur in offshore Mississippi waters in the spring through the fall but rarely at salinities below 21 ppt
- zoeae are filter feeders but specific food habits are not known;
- megalopae enter coastal waters and occur throughout the year with peak abundances in late summer and early fall
- megalopae are omnivorous and include fish and shellfish larvae and aquatic plants in their diet.

Juveniles

- tolerate wide range of temperature and salinity
- occur in estuaries year-round; peaks in the summer and winter
- high occurrences over soft mud bottoms and in shoreline marshes
- greatest abundance in coastal bays and Mississippi Sound waters north of Intracoastal Waterway
- feed on molluscs, crustaceans, fish, vegetation and detritus

Other Information

The blue crab fishery is one of the most important local commercial fisheries. In 1980 over 2.7 million pounds of blue crab, having a dockside value of $693,000, were landed in Mississippi. Small blue crabs are a select food item of commercially and recreationally important sciaenid fishes (trouts).

Pink shrimp - Penaeus duorarum

Adults

- maturity reached during first year, generally in offshore waters
- prefer moderate to high salinities (20 ppt and higher)
- greatest concentrations of harvestable shrimp are found in the Gulf at depths between 11 m and 37 m
- prefer sand, shell/sand and coral/mud bottoms, a factor which limits distribution
- omnivorous feeding habits; combine predation with detrital feeding; prey include polychaetes, nematodes, caridean shrimp, mysids and copepods
- peak spawning believed to occur offshore from the early summer through the fall; may be continuous in deeper waters throughout the year

Eggs

- demersal

Larvae

- develop in offshore Gulf waters
- feed on plankton and suspended detritus

Postlarvae

- found in Mississippi estuarine waters from July through December; occurrence generally peaking from August-September, depending on salinities
- found over a temperature range of 4-34° C
- prefer moderate to high salinities (20 ppt and higher)
- feed largely at night by scavenging on bottom as well as feeding on suspended detritus

Juveniles

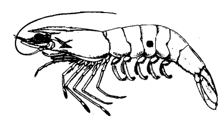
- most abundant around offshore barrier islands near submerged vegetation
- omnivorous feeding habits, fecal pellets being an important food source

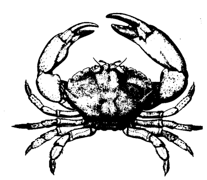
Subadults

- found in inshore waters and near barrier islands during the fall, winter and spring

Other Information

Over 377,000 pounds (heads-on) of pink shrimp with a dockside value of $874,000 were landed in Mississippi in 1982. Penaeus duorarum comprised 3% of the shrimp off-loaded at Mississippi docks from 1979-1982.





Stone crab - Menippe mercenaria

Adults

- common at salinities above 15.0 ppt
- found primarily over mud bottoms near the barrier islands, also found near channels and bottom obstructions
- appear in greatest numbers from March through June in the southern region of Mississippi Sound
- inshore populations dominated by females; populations south of the barrier islands dominated by males

Eggs

- sponge crabs found from April through October in the mid to outer regions of Mississippi Sound in salinities above 15.0 ppt
- approximately 10,000-50,000 eggs per sponge
- sponge carried by females for 4 to 6 weeks, turning from a bright orange to brown in color

Larvae

- development consists of 5 zoeal stages and 1 megalopae stage
- all larval stages found occurring together, indicating that development is completed entirely within local waters
- occur in outer Mississippi Sound and adjacent offshore waters in salinities above 15.0 ppt

Juveniles

- common on hard bottoms, e.g. oyster bottoms, and on bottom obstructions over mud bottoms
- common at salinities above 10.0 ppt
- peak abundance of small juveniles (below 3 mm) observed in July and August
- reach maturity in about 2 years at a carapace width of 30 mm

Other Information

Since 1979, stone crabs have entered the Mississippi blue crab fishery in increasing numbers. A small local market is developing.

Mississippi Department of Wildlife Conservation
Bureau of Marine Resources
Long Beach, Mississippi 39560

TABLE 3-4

Endangered and rare vertebrate species known to occur within the coastal counties or associated marine waters of Mississippi.*

ENDANGERED SPECIES

Acipenser oxyrhynchus (Atlantic sturgeon)
Alligator mississippiensis (American alligator)
Drymarchon corais couperi (Eastern indigo snake)
Chelonia mydas mydas (Atlantic green turtle)
Caretta caretta caretta (Atlantic loggerhead turtle)
Lepidochelys kempii (Atlantic ridley turtle)
Dermochelys coriacea (Leatherback turtle)
Grus canadensis pulla (Mississippi sandhill crane)
Haliaeetus leucocephalus (Bald eagle)
Falco peregrinus (Peregrine falcon)
Pelecanus occidentalis (Brown pelican)
Picoides borealis (Red-cockaded woodpecker)
Trichechus manatus (West Indian (Florida) manatee)
Felis concolor coryi (Florida panther)
Canis rufus (Red wolf)
Whales, several species

RARE SPECIES

Cemophora coccinea (Scarlet snake)
Deirochelys reticularia (Chicken turtle)
Gopherus polyphemus (Gopher tortoise)
Lampropeltis calligaster rhombomaculata (Mole snake)
Lampropeltis triangulum elapsoides (Scarlet kingsnake)
Macrochelys temmincki (Alligator snapping turtle)
Micrurus fulvius fulvius (Coral snake)
Rhadinaea flavilata (Yellow-lipped snake)
Accipiter striatus (Sharp-shinned hawk)
Anas fulvigula (Mottled duck)
Aquila chrysaetos (Golden eagle)
Charadrius alexandrinus (Snowy plover)
Coturnicops noveboracensis (Yellow rail)
Dichromanassa rufescens (Reddish egret)
Elanoides forficatus (Swallowtail kite)
Gelochelidon nilotica (Gull-billed tern)
Haematopus palliatus (American oystercatcher)
Lateralius jamaicensis (Black rail)
Sterna antillarum (Least tern)
Tyrannus dominicensis (Gray kingbird)
Myotis lucifugus (Little brown bat)

*This list includes species other than those known to occur in Mississippi coastal waters or known to be closely associated with these coastal waters.

Source: Mississippi Natural Heritage Program, Mississippi Department of Wildlife Conservation.

ESTIMATED MAXIMUM TIDAL CURRENTS FOR SELECTED PASSES IN MISSISSIPPI COASTAL WATERS

Prepared for

Mississippi Department of Wildlife Conservation
Bureau of Marine Resources
Long Beach, Mississippi

Prepared by

Charles K. Eleuterius
Physical Oceanography Section
Gulf Coast Research Laboratory
Ocean Springs, Mississippi

BMR Project No. CO-OCS-84-004
April 1984

TABLE 3-5

INTRODUCTION

The judicious planning and execution of protective measures and cleanup operations in the event of an oil spill require knowledge of the expected maximum currents. When oil spills are of concern, the importance of the prevailing currents is two-fold: first, because currents are the primary mechanism for the transport of crude oil released into the marine waters; and second, because their magnitudes must be considered in the selection and deployment of containment devices. Oil spills may occur as a result of accidents associated with tankers, drilling operations, transfer operations, and submarine pipelines. The probability of the occurrence of an oil spill within the state's productive marine waters increases as the exploration and development of oil reserves beneath the Mississippi Sound, contiguous waters of neighboring states, and U.S. territorial waters increase. This paper presents the methods and results of an effort to estimate the maximum tidal current speeds for certain areas in Mississippi coastal waters for use as a guide in the event of an oil spill.

For the preparation of an oil spill contingency plan for Mississippi's coastal marine waters, the Mississippi Bureau of Marine Resources identified certain areas for which the maximum current speeds were needed. These areas are entrances to highly productive estuarine nursery areas, characterized by salt marshes for which crude-oil cleanup is literally impossible. It was requested that current speeds be determined for typical storm tides superimposed on maximum astronomical tides and, in the case of subsequent outflow (ebb tide), to include the additional effect of the contribution of maximum freshwater drainage from the associated watershed. The study areas, located on the perimeter of Mississippi Sound, are affected by the forces that dictate the hydrodynamic nature of the Sound.

The primary causes of circulation in Mississippi Sound are tides, density differences, wind stress, and river discharge--tides being the most important. The tides of Mississippi Sound and the contiguous study areas are those of the Gulf of Mexico, but modified by the three-dimensional geometry of the area through and over which the tide waves pass. The tides of the study area are predominantly diurnal. The tide wave varies in its diurnal range around the Sound and is further modified by strong winds that, depending upon the wind direction, either act to reduce or increase its amplitude. Heavy rainfall in the watersheds that accompanies severe weather conditions also adds to the total volume of the outflow. This effort to ascertain the maximum current speeds for the areas was limited to the tides but as modified by conditions described here. Currents generated by other causes were considered negligible in comparison.

METHODS AND MATERIALS

To derive the expected maximum current speeds, specific information on the areas regarding their configurations and depths was needed. This information was obtained for the area first by acquisition of bathymetric profiles along transects across the areas of interest. Because of the extreme shallowness of most of the areas, particularly at the margins, and the need to obtain as complete a record of the bathymetric relief as possible, an 18-ft jon boat with outboard power was used. A SI-TEX HONDA, HE-356, which has circuitry that eliminates secondary signals, was used to obtain the bottom profiles. This unit was calibrated and the depth of the sensor below the water surface with the boat underway was recorded.

Prior to the running of the transects, reference posts were implaced at approximately mean sea level (MSL) at each end of the transect based on Coast and Geodetic charts and NOAA small craft hydrographic charts. The usual shallow depths located near the ends of the transects prevented acquisition of a complete bathymetric record. The distances from the starting and stopping points of the boat to the nearest reference post were measured by precision optical range finders (Ranging, model 103X and model 600). The slope of the bottom over thse distances was assumed to be constant.

For purposes of discussion, the transects were given names that could be easily associated with the areas for which they were taken. Transects for Biloxi Bay are shown in Figure 1: transect A is also referred to as Biloxi Bay-Railroad Bridge; transect B, Biloxi Bay-east entrance; transect C, Biloxi Bay-west entrance; transect D, Davis Bayou. Figure 2 shows the transects run in east Mississippi Sound: transect E, Middle Bay; transect F, Jose Bay; transect G, Bangs Bayou. Transects taken in the Pascagoula River are shown in Figure 3: transect H, Pascagoula River-East Mouth; transect J, West Pascagoula River-Railroad Bridge; transect K, West Pascagoula-Highway Bridge. Transect L, Graveline Bayou, is shown in Figure 4. The transect at Horn Island, M, is located in Figure 5. The two transects, N and O, on Cat Island (Figure 6) are referred to as South Bayou and North Bayou, respectively. The final transect, P, St. Louis Bay, is depicted in Figure 7.

The analog form of the bathymetric profiles had to undergo a sequence of operations to put the data in a form for analysis. The bathymetric records, corrected for depth of the sensor, were digitized with a H. Del Foster, model RSS-4 planimeter that has a resolution of .001 inch. The length of the transect from reference point to reference point as obtained from the latest aerial photographs by the combined use of a Krones transcope enlarger model LZK-100 and the RSS-4 planimeter. These data were then encoded for computer processing. Scale transition was required to put the digitized coordinates into actual units of measure of distance and depth in the prototype. Because of the need to use multiple vertical scales along some transects, conversion of the Y-coordinate values (depth) required special attention at points of scale change to maintain accuracy in the converted bathymetric profiles. The depths were simultaneously adjusted to the 1929 mean sea level datum based on tidal charts from the U.S. Army Corps of Engineers' gauging stations nearest the transect locations. The transect end segments which could not be profiled were accounted for during the horizontal scale conversion.

The tides of Mississippi Sound are predominantly dirunal with the main tidal components being luni-solar diurnal, principal lunar diurnal, and the principal solar dirunal; with periods of 23.93 hours, 25.82 hours, and 24.07 hours, respectively. Because of the angle of incidence of the tide wave and the physical configuration of the Sound, the tidal range is different for different areas of the Sound. The maximum astronomical tides produce spring diurnal tidal ranges of approximately 2.5 feet and neap tidal ranges of approximately 1 foot. The diurnal tides are superimposed upon tidal components of much longer period, which, dependent upon the stage of the longer period components, affects the diurnal tidal reach upon the tidal plane. Setup along the shore due to surf beat or wind stress also affects the water elevation. Tidal currents represent the motion of the water particles in the progressive tide wave.

Tide waves in estuaries are complex phenomena that are difficult to describe completely in mathematical terms. Many of their characteristics, however, can be described within acceptable limits by linear wave theory. Making the normal linear wave theory assumptions of an impermeable, immovable bottom, incompressible fluid, irrotational motion, and slippage along the boundaries, the two-dimensional form of the wave equation is

$$\eta = a \cos (kx - \sigma t)$$

where η = the ordinate of the water surface

k = wave number

σ = angular frequency

t = time

x = horizontal coordinate

a = amplitude of the wave.

Shifting the original and making appropriate substitutions gives

$$\eta = \frac{H}{2} \cos 2\pi(\frac{x}{L} - \frac{t}{T})$$

where H = wave height

L = wave length

T = wave period.

The corresponding horizontal component of water particle velocity in this progressive wave is

$$U = \frac{gHT}{2L} \frac{\cosh 2\pi(y-d)/L}{\cosh 2\pi d/L} \cos 2\pi(\frac{x}{L} - \frac{t}{T})$$

where g = gravitational acceleration

y = position within the wave

d = stillwater depth.

Under linear wave theory, the phase speed of the wave is

$$C = \sqrt{\frac{gL}{2\pi} \tanh \frac{2\pi d}{L}} .$$

The form of the equation for phase speed for the case of shallow water waves, i.e. when the water depth is equal to or less than one-half the wave length, reduces to

$$C = \sqrt{gd} .$$

With further simplifications and some mathematical manipulation, the horizontal component of water particle velocity becomes

$$U = \frac{H}{2} \sqrt{\frac{g}{d}} \cos 2\pi(\frac{x}{L} - \frac{t}{T}) .$$

Without friction, as the equation indicates, the horizontal component of particle velocity is independent of distance below the stillwater level.

The shallower the water, the greater the effect of friction upon the tidal currents. In shallow water, the tide and the tidal currents will be modified by the friction to which the waters are subjected when moving over the bottom. The bottom and lateral friction influences the currents to a considerable distance from these boundaries due to the turbulent character of the flow. One expression for the horizontal component of velocity that takes into account the frictional dissipation is the following one-dimensional form of motion for long waves.

$$U = -g \frac{\partial \eta}{\partial x} - g \frac{u|u|}{C^2 R}$$

where u = horizontal component of velocity unadjusted for friction

R = hydraulic radius

C = Chezy coefficient.

The hydraulic radius is the cross-sectional area divided by the wetted perimeter of the cross section. This form of the Chezy coefficient requires the use of the Darcy coefficient which, for the sake of this study, was also numerically equal to the Manning coefficient for roughness of sand.

The design waves to be used in this study had to reflect the approximate height, shape, and period of the actual tide waves that might occur. A sine function was used to describe the general form of the wave and thereby dictated the tide phase. A wave period of 24 hours was selected based upon the predominantly dirunal nature of the local tides and the periods of the main diurnal tidal components. The maximum diurnal tidal ranges for each of the respective sites were taken from the NOAA tide tables for the nearest gauging stations. The historical tide charts archived at Gulf Coast Research Laboratory were inspected for extraordinary high tides caused by severe weather conditions. The weather-generated tide amounted to about 2 feet above the maximum astronomical tide. Maximum water elevations to be expected, except in instances of tropical storms, were obtained by first specifying the stillwater level as being at mean sea level, and further specifying an increased 2-ft water elevation caused by severe weather superimposed upon and in phase with the maximum astronomical tide. The weather associated tide for this study is assumed to have the same period as the astronomical tide. This set of parameters describes the design waves used for estimating the currents during the flood stage.

The effect on current speeds caused by the addition of fresh water from the watersheds during tidal ebb was also addressed. The watershed area was first delineated and then measured with the planimeter identified earlier. In some areas where the watershed consisted almost entirely of marsh, the determination of the boundaries of the watersheds became largely subjective. From the rainfall and river discharge records, it was calculated that at a precipitation rate of 2 in hr^{-1} occurring uniformly over the watershed, an additional 50 ft^3 sec^{-1} for each square mile of drainage area entered the waters of interest. A further assumption was that after some time lag, the inflow reached and maintained its maximum rate prior to commencement of the ebb stage which allowed the inflow to be uniformly distributed along the length of the transect. This volume of freshwater discharge through the transect area would be manifested in additional height to the receding "tide" wave. In the cases where the outflow was divided between multiple outlets (Biloxi Bay and Pascagoula River), the total discharge, for lack of more exacting information, was partitioned in proportion to the percentage of their cross-sectional areas to the sum of the cross-sectional areas of the passages involved. It should be noted that the transfer of momentum due to river discharge was beyond the scope of this study. The contribution that the additional fresh water made was added to the wave height to compute current speeds during ebb stage.

The number of steps and simplifying assumptions were made prior to the comupter runs. The numerical analogs were derived and coded in the Fortran IV computer language. The computer program was encoded into the computer and a number of tests were conducted to test the operation of the algorithm. Data for each site included the bathymetric profile, adjustment for rainfall, and maximum astronomical tide. The angle of incidence of the tide wave was assumed normal to the plane of the transect cross section. The tide wave was assumed to be entering a channel of infinite length and of irregular, but constant cross section. The lateral boundaries at the reference points were taken to be vertical walls of infinite height.

RESULTS AND DISCUSSION

The maximum current speeds for ebb and flood stages appear in Table 1. The table also includes information on the width, cross-sectional area, average depth, maximum depth, and wetted perimeter for each transect site. The speeds for sites with very shallow waters were adjusted for friction: those for the sites with deeper waters were not. The speeds reported are merely approximations because of the necessary assumptions made and techniques employed, and therefore should be used only as a guide. Comparisons of the calculated maximum astronomical current speeds with actual current measurements for Biloxi Bay and St. Louis Bay were in good agreement.

There are a number of things to be considered further as regards the currents in these areas. First, in the area of Pascagoula River, especially the east mouth, the tidal influence while seen as a change in water elevation is usually manifested in the form of a salinity wedge confined to the lower water column. One should therefore anticipate, except in severe weather conditions, either small inward flows at the surface or seaward flows at all times. Such a stratified flow in the opposite direction is beyond the two-dimensional form of the wave equation used in this study. Second, the estimates of current speed did not allow for reflection of the tide wave. Third, the tidal charts indicate a longer time period between low water and high water than between high water and low water. The use of the symmetrical sine funtion does not account for this skewed tide wave form. The shorter period between high water and low water would result in slightly higher current speeds during the ebb stage than occur during the flood stage. Last, much of the terrain adjoining the transects consists of extensive salt marshes. During high water, many of these areas, depending upon the total water elevation, will be inundated. Therefore, the widths reported in Table 1 should not be used alone to determine the required boom length. Despite the many complexing factors, the estimates are considered to be fairly accurate.

RECOMMENDATIONS

To obtain greater accuracy in the determination of the maximum current speeds, the following suggestions are made. Field measurements of currents taken simultaneously and in close proximity with water elevation measurements should be made during the spring tidal period. These records would incorporate the effect of friction as well as the reflection of the tide wave. These data could be used to tailor or calibrate a form of the long wave equation for each area of concern. To acquire a more comprehensive picture of the current regime for the areas, either a finite element or finite difference modeling effort could be conducted. Because of the complexity caused by stratified flow and the effect of the marsh upon the hydrodynamics, such a study would be costly if done properly.

ACKNOWLEDGEMENTS

I wish to express my appreciation to Mr. Alan Criss who contributed substantially to this project. I also wish to thank Mrs. Joyce Edwards for her efforts in data acquisition, data verification, and manuscript preparation. Thanks are also due Mrs. Cynthia Dickens who prepared the final transcript. Mrs. Sandra Thames prepared all of the illustrations.

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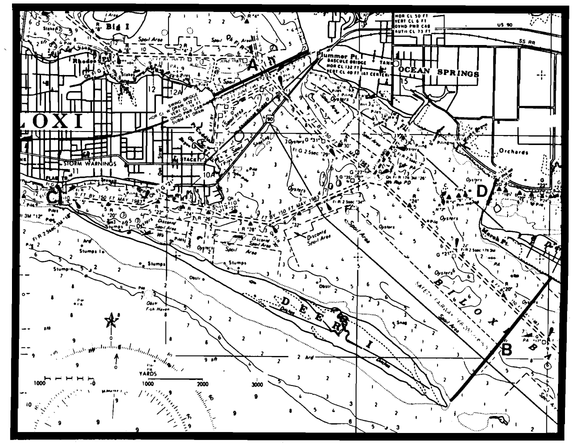

Figure 1. Transect locations in Biloxi Bay. Transects A, B, C and D. See Base Map 4 (p. 2-9) for area shown in Figure 1.

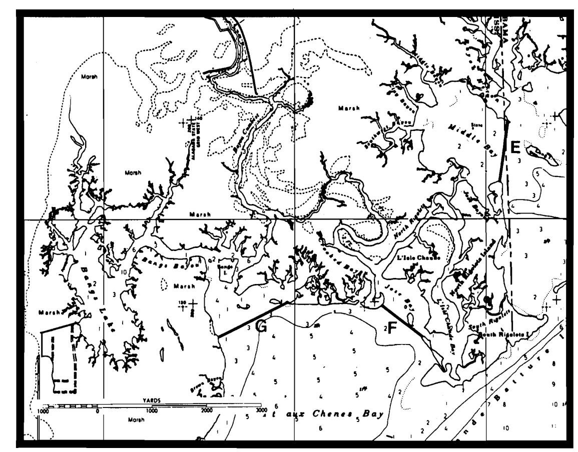

Figure 2. Transect locations in east Mississippi. Transects E, F and G. See Base Map 6 (p. 2-17) for area shown in Figure 2.

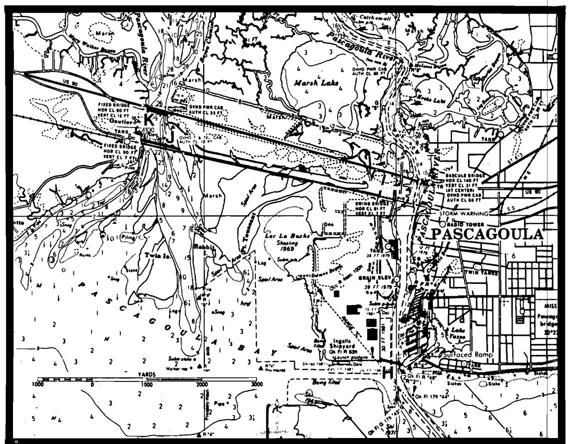

Figure 3. Transect locations in the Pascagoula River. Transects H, J and K. See Base Maps 5 (p. 2-13) and 6 (p. 2-17) for area shown in Figure 3.

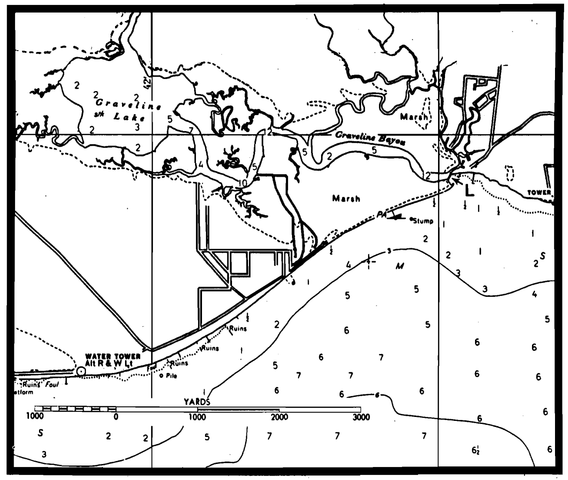

Figure 4. Transect location in Graveline Bayou. Transect L. See Base Map 5 (p. 2-13) for area shown in Figure 4.

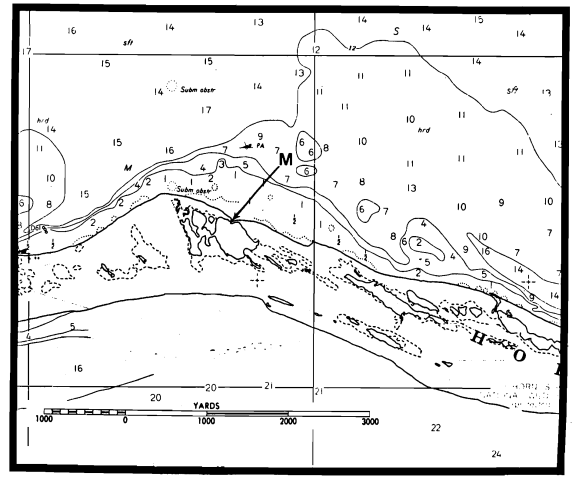

Figure 5. Transect location at Big Lagoon, Horn Island. Transect M. See Base Map 10 (p. 2-29) for area shown in Figure 5.

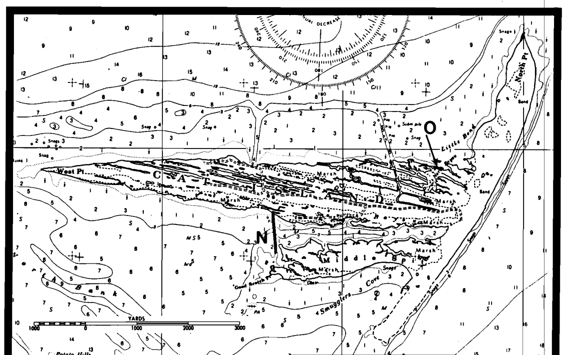

Figure 6. Transect locations at Cat Island. Transects N and O. See Base Map 8 (p. 2-23) for area shown in Figure 6.

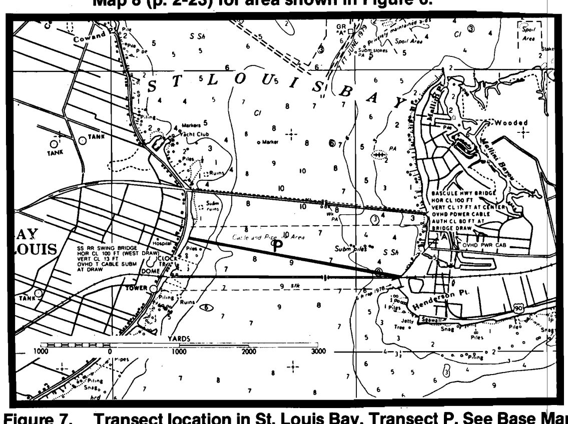

Figure 7. Transect location in St. Louis Bay. Transect P. See Base Map 2 (p. 2-5) for area shown in Figure 7.

Dimensional measurements and maximum current speeds for selected passes in Mississippi coastal waters.

Transect identification letters*	Transect locations	Width (feet)	Cross section area (sq. ft.)	Average depth (feet)	Maximum depth (feet)	Perimeter (feet)	Maximum inflow (knots)	Maximum outflow (knots)
A	Biloxi Bay (R/R Bridge)	5,667	44,428	7.83	18.16	5,720	2.45	2.60
B	Biloxi Bay (East Entrance)	8,848	53,827	6.08	14.75	8,894	2.57	2.66
C	Biloxi Bay (West Entrance)	658	7,920	12.03	17.79	688	2.50	2.81
D	Davis Bayou	2,102	5,434	2.58	8.35	2,105	2.70	2.75
E	Middle Bay	3,462	13,409	3.87	5.38	3,464	2.18	2.19
F	Jose Bay	2,972	9,123	3.06	4.24	2,975	2.63	2.64
G	Bangs Bayou	4,553	16,847	3.70	5.24	4,556	2.67	2.70
H	Pascagoula River (East Mouth)	1,213	45,024	37.11	60.64	1,357	1.18	1.93
J	Pascagoula River (West, R/R Bridge)	2,182	33,448	15.32	25.13	2,240	1.84	2.38
K	Pascagoula River (West, Highway Bridge)	1,486	34,865	23.46	34.03	1,602	1.48	2.16
L	Graveline Bayou	364	3,475	9.54	13.38	370	2.62	2.83
M	Horn Island, Big Lagoon	50	102	2.00	3.50	54	2.62	2.65
N	Cat Island, South Bayou	3,375	6,324	1.87	5.19	7,779	2.64	2.66
O	Cat Island, North Bayou	587	976	1.66	3.18	589	2.60	2.62
P	St. Louis Bay	9,994	74,256	7.43	10.66	10,035	2.65	2.77

* No Transect I.

TABLE 3-6

WASTE OIL COLLECTION COMPANIES LOCATED IN THE MISSISSIPPI GULF COAST AREA

1. WASTE OIL COMPANY
MR. SHELTON CAMBRE
P. O. BOX 330
GAUTIER, MS 39553
PHONE: 497-4585 OR 762-8065

2. DISPOSAL SYSTEMS, INC.
MR. JIM PHILLIPS
P. O. BOX 404
BILOXI, MS 39533
PHONE: 374-2064