Calibrating a Biological Condition Gradient Model to the Mobile Bay Estuary

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Introduction

EPA Region 1 funded the project entitled "Calibrating a Biological Condition Gradient Model to the Mobile Bay Estuary". This report documents technical support for Mobile Bay National Estuary Program (MBNEP) efforts to calibrate a Biological Condition Gradient (BCG) model (Davies and Jackson, 2006) of environmental assessment to coastal Alabama. The MBNEP is identifying biological indicators to gauge progress toward meeting the objectives and goals established in its Comprehensive Conservation and Management Plan. The MBNEP and its Science Advisory Committee (SAC) intend to use the BCG model to assess and communicate to the public the health of the estuary, using biological information and stressor assessment to measure estuarine status and trends.

This report documents BCG framework development to date, including recommendations for biological indicator and database development. The first step in BCG framework development was a review of past efforts to identify biological indicators for assessment of the MBNEP study area (Attachment 1). Attachment 2 contains background information on historic anthropogenic alteration of the Alabama estuary. A description of the estuary is presented in Attachment 3, including maps of physical and biological features. Attachment 4 includes maps of historic and recent SAV and oyster reef distributions in the study area.

BCG Framework Development to Date

After evaluating the potential of previously identified indicators for use in a BCG framework (Attachment 1), two approaches were considered by the SAC: 1) Restoration of a historic acreage balance among different habitats and 2) Monitoring of soft-sediment benthic invertebrates as indicators of biological integrity. In May 2011 the SAC initially opted to pursue a BCG approach based on recent historic change in both the quantity and quality of coastal habitats, similar to the Tampa Bay restoring balance approach.

After further consideration and discussions among SAC members in August 2011, it was concluded that that seeking to restore a proportional balance of acreage among habitats did not capture the productive aspects of the estuary. It was also recognized that the need to translate biological condition and environmental trends into something that people use or look at would most effectively convey estuarine condition to the public. The SAC was concerned that a restoring balance framework would not address important community uses and the ecosystem services that support them. There was general agreement over the importance of ecosystem services driving the prioritization of habitats and resources to be monitored, and that restoration efforts address the anthropogenic stressors that deteriorate the estuary's biological condition.

The SAC proceeded to determine which ecosystem services and habitats are most imperiled, based on their vulnerability to a host of present-day stressors. A list of priority habitats previously identified by the MBNEP (Stout et al., 1998; TNC, 2009) was compiled, along with a list of their ecosystem services and various anthropogenic stressors in the study area. Stressor consideration was limited to those whose impacts can be mitigated through adaptation or policy change. The intent was to rate present-day stressor impacts, not historic or potential impacts.

First the members of the SAC, then an additional 17 scientists, completed a Habitat and Ecosystem Service Evaluation Sheet. The evaluation matrix included 12 ecosystem services, 12 priority habitats, and 13 stressors (Table 1-1). Scientists completed this evaluation by rating on a scale of 0 (no impact) through 3 (high impact) the present-day level of impact that each stressor has on the ecosystem services provided by the individual priority habitats. Evaluators were asked to leave blank any combination of stressor, ecosystem service, or habitat that was outside of their expertise.

Based on the estimated average stress levels, the ecosystem services under the most stress in coastal Alabama are biodiversity, wildlife habitat, water quality, and primary production (Table 1-1). Habitats with the greatest amount of stress on their ecosystem services are freshwater wetlands, intertidal marshes and flats, riparian buffers and streams and rivers. Stressors having the most impact on estuarine condition are land use change, habitat fragmentation, dredging and filling, and sedimentation.

Table 1-1. Ecosystem services, priority habitats, and stressors evaluated in the Habitat and Ecosystem Service Evaluation Sheet.

Ecosystem Services	Priority Habitats	Anthropogenic Stressors
Biodiversity 231.2[1]	Freshwater wetlands 248.9[2]	Land use change 227.0[3]
Wildlife habitat 216.2	Intertidal marshes and flats 230.4	Habitat fragmentation 194.0
Water quality enhancement 200.0	Riparian buffers 211.0	Dredging and filling 189.5
Primary production 177.6	Streams and rivers 200.5	Sedimentation 182.1
Nesting habitat for birds and turtles 167.8	Longleaf pine habitat 180.7	Freshwater discharge 160.9
Fisheries habitat 161.5	Oyster reefs 171.3	Resource extraction 153.6
Carbon sequestration 157.2	Pine savanna forest 169.2	Climate variability 149.2
Sediment and nutrient retention and export 157.2	Maritime forest 162.3	Nutrient enrichment 144.1
Storm buffer/hazard protection 151.2	Submerged aquatic vegetation 149.0	Sea level rise 141.7
Flood control 129.5	Beaches and dunes 139.3	Invasive species 139.3
Groundwater replenishment 122.2	Subtidal habitats 124.8	Chemical contamination 124.3
Oyster production 96.6		Pathogens 97.8
		Fire suppression 83.9

[1]Sum of average stress among priority habitats for all stressors combined
[2]Sum of average stress among ecosystem services for all stressors combined
[3]Sum of average stress for all ecosystem services/priority habitats combined

Vision Statement

Significant environmental degradation has occurred historically in coastal Alabama, especially due to habitat destruction and hydrologic alteration of the watersheds draining into Mobile Bay, Mississippi Sound, and Perdido Bay. Some portion of the cumulative ecological impacts of human activities has remediation potential, but much of the historic change, particularly land conversion, is irreversible. Land use change, habitat fragmentation, erosion, and sedimentation continue to affect the estuarine condition through hydrologic connectivity with local watersheds. Maintaining and enhancing the natural ecological functions of priority coastal habitats will help sustain a productive estuary and improve water quality in local watersheds, Mobile Bay, and adjacent tidal waters.

Because of the ecological diversity and complexity of the Alabama coast, achieving and maintaining a productive and healthy estuary will require a sustained effort that addresses the myriad of human-caused stressors on the extent and quality of intertidal marshes and flats, freshwater wetlands, streams, rivers, and riparian buffers. The MBNEP vision of an ideal ecological state is a productive estuary comprised of priority habitats in good condition, equivalent to reference standards providing natural levels of ecosystem function. Habitats with the highest levels of functional capacity are assumed to have the potential to provide the full range of ecosystem services expected under natural, minimally disturbed conditions.

Recommendations

According to EPA the most applicable attributes for estuarine BCG include ecosystem function, habitat connectivity, and habitat mosaics. Measuring habitat quality and ecosystem services provision addresses the function aspect. The mosaic of rivers and streams, coastal wetlands, and ultimately Mobile Bay and its environs incorporates structural and functional connectivity of the landscape into a whole-estuary framework.

It is expected that a range of biological values will be identified for each ecosystem service or habitat metric to correspond to BCG condition tiers. Ideally, the individual parts of the BCG framework will collectively comprise a broad measure of estuarine condition as it relates to regional stressors.

Wetland Quality Assessment

The quality of coastal wetlands can be determined using one or more rapid assessment methods that are widely recognized as valuable tools for measuring the status of these resources. Rapid assessment methods hold a central position in monitoring programs because once established, they can provide sound, quantitative information on the status of the wetland resource with a relatively small investment of time and effort (Fennessy et al., 2004). Many assessment methods assign numerical values to wetland functions, and the quantifiable aspect is well suited for use in a BCG framework.

There are existing wetland quality indices suitable for status and trends assessment in the MBNEP study area, notably the hydrogeomorphic (HGM) approach. HGM is a collection of concepts and methods that use mathematically derived indices to assess the capacity of a wetland to perform specific ecological, geochemical, and hydrological functions in comparison to similar wetlands within a geographic region. HGM involves both a remote sensing component and field assessment. Beever et al. (2013) reviewed the effectiveness of three wetland functional assessment methods used widely for regulatory purposes -- HGM, Wetland Rapid Assessment Procedure (WRAP), and the State of Florida's Uniform Mitigation Assessment Method (UMAM) – and determined that HGM was the most appropriate method because of the thorough scientific review involved in its development. One advantage of the HGM approach is that an individual site may be assessed for a suite of functions or a subset of functions, as determined by project management objectives.

An HGM guidebook for tidal marshes was produced Shafer et al. (2007) for application to the Alabama coastal area. It is recommended that the SAC consider adopting this HGM index to assess and track habitat function and quality for study area tidal marshes. For other wetland types in the study area it is recommended that an HGM approach or other wetland condition index also be adopted for quantifying habitat function and quality.

High quality reference wetlands will provide a baseline of minimally degraded conditions for each wetland type in the study area. The MS-AL Habitat Mapper identifies Priority Conservation Wetlands (TNC, 2009), including riparian areas, which are potentially useful as preliminary reference wetlands in the BCG. The Mobile-Tensaw Delta contains high quality riverine wetlands suitable as minimally degraded reference locations, and high quality salt marsh is extensive along the southern Mobile County mainland. Refinement of the wetland database through additional studies would more precisely identify locations containing the highest quality wetlands. Reference site conditions will represent the best range of minimally impaired conditions that can be achieved within each wetland classification category in the MBNEP area. A BCG metric for habitat quality could include average condition of a given wetland category (tidal marsh, riverine forested, etc.), as determined by HGM or other assessment methodology.

Clean Water Act Section 404 regulations allow wetland destruction or use under certain circumstances. Special conditions attached to such impacts may include compensatory mitigation, but as a practical matter the loss of wetland values is likely to continue to occur for the foreseeable future. A wetland acreage goal of no net loss therefore is not realistic. Potential options for wetland metrics addressing acreage could include a reduced rate of wetland loss, acres of quality enhancement of degraded wetlands, and acres of restoration at locations where wetlands had occurred in the past. Consideration should be given to limiting certain acreage goals to the coastal zone (below the 10-ft elevation contour), where wetlands are afforded greater regulatory protection. The percentage of wetland acreage protected by conservation easements is potentially an appropriate metric to include in the BCG framework.

Streams and Rivers

The State of Alabama does not have a numeric index of biological integrity (IBI) calibrated for streams and rivers in the coastal area. The ADEM uses a combination of physical and biological data to assess water quality in coastal streams and rivers based on narrative criteria. The SAC should assess the practicability of calibrating an IBI for wadable streams in the study area. Stream IBI metrics typically include measures for assemblage composition, taxa richness, perturbation tolerance/intolerance, and trophic characteristics (Barbour et al., 1999).

O'Neil and Shepard (GSA, 2012) investigated a limited number of Coastal Plains streams in Mobile and Baldwin Counties using a fish IBI, and found condition at 21 stream reaches ranged from good to very poor. The GSA IBI is a freshwater index, and its utility for streams in proximity to estuarine waters is unknown.

Though not based on biota, the Rosgen (1996) stream classification system categorizes various stream types by morphological characteristics, including stream gradient, sinuosity, width/depth ratio, channel materials, entrenchment, confinement, and soil/landform features. Potential applications of the Rosgen Index include riparian management guidelines and fisheries habitat interpretations, but the relationship between stream morphology and biological communities has not been validated for the MBNEP study area.

The MS-AL Habitat Mapper identifies Priority Conservation Streams (TNC, 2009), which potentially can inform the location of streams or stream reaches representing minimally impaired reference conditions. A BCG metric for stream quality could include average stream condition, as determined by an IBI or other quality index. The percentage of total stream reach length listed as impaired under the ADEM 303d assessment program is potentially an appropriate metric to include in the BCG framework.

Indicators for Mobile Bay

Land use change was identified in the habitat and ecosystem services evaluation as the most impactful stressor in the study area, and sedimentation also ranked high. However, the relationship between land use change in local watersheds and downstream biological condition is, depending on the potential indicator, poorly or incompletely understood in the MBNEP study area. Identifying aquatic biota suitable for indicator use in Mobile Bay and adjacent subtidal waters has been problematic. The ecosystem components that appear most usable in a biotic assessment of the estuarine condition of Mobile Bay and other subtidal waters are those benthic habitat types that constitute the predominant substrata: unconsolidated sediments, oyster reefs, and submerged aquatic vegetation.

The feasibility of a BCG approach based on benthic macroinvertebrates as indicators of sediment and water quality was addressed in the indicator review (Attachment 1) and considered during subsequent deliberations of the SAC. While macroinvertebrate IBIs are a commonly used method for water quality assessment, major hurdles with this approach for Mobile Bay include a lack of a historical baseline or benchmark that could be used to detect the impacts of coastal development on soft sediment habitats within the MBNEP study area (Stout et al., 1998). Moreover, routine monitoring of sediment benthos would entail high monetary costs.

Both oyster reefs and SAV are indicators of water quality and are important for fisheries production, and both have declined significantly in extent compared to their historic occurrences. Attachment 4 includes maps showing differences in historic (1940, 1955, 1966) and recent (2002) SAV occurrence for portions of the study area, and for historic (1882, 1968) and recent

(1995) oyster reef distribution. Oyster reefs occur mostly in the southern half of Mobile Bay and in Mississippi Sound, whereas SAV is more widespread the study area, including in smaller bays and upstream water bodies.

The historic decline in SAV was coincident with increased land cover change in the MBNEP study area, particularly increases in impervious surfaces and urbanization. Declines in SAV extent are believed to be principally the result of increasing inputs of sediments and nutrients into estuarine waters, which increase turbidity and reduce light availability necessary for plant growth and survival. Improvement of water quality through effective watershed management would presumably result in better conditions to support SAV. SAV therefore has potential as an estuarine condition indicator, particularly at locations near open bay waters where it occurred historically. Before incorporating an SAV indicator in the BCG framework it may be prudent to first assess potential SAV restoration locations with respect to existing conditions (water quality, light regime, physico-chemical), to evaluate the potential for eventual success.

Adequacy of the Existing Ecosystem Inventory

It is recommended that a remote sensing strategy be used for MBNEP ecosystem monitoring. Analysis of aerial imagery, combined with surface level observations, is a cost-effective method to determine long-term trends and short-term changes in wetlands and other natural features. A database of spatial distribution and habitat quality should be periodically updated and refined to account for future landscape change, and to ensure consistency and accuracy of habitat characterizations.

The existing MBNEP spatial database is the MS-AL Habitat Mapper, which contains location data for coastal wetlands and watercourses. The Habitat Mapper is based on Alabama GAP data (2001), which was developed using Landsat Thematic Mapper and Landsat Enhanced Thematic Mapper satellite imagery. The imagery consists of raster-based land-cover maps at 30-meter resolution. Such coarse resolution data present methodological difficulties in creating spatially accurate land cover classification. At coarse resolution, pixels often contain a mixture of cover types even in a fairly general classification scheme, creating difficulty in deciding on the correctness of the assigned label. Because of this, raster-based imagery data set is best used as a screening tool for broad management decisions. Small features and temporal changes are best verified with native imagery at a higher resolution. It is recommended that high-resolution mapping of wetlands be performed in the development of an enhanced resource database.

It is recommended also that wetland boundaries be delineated using the methods described and outlined in the 1987 U.S. Army Corps of Engineers Wetland Delineation Manual. The 3-parameter approach to identifying and delineating wetlands includes 1) presence of hydric soils; 2) evidence of wetland hydrology; and 3) a predominance of hydrophytic vegetation. This methodology is consistent with Clean Water Act Section 404 assessment, used to identify wetlands afforded State and Federal protection.

References

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling, 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Beever, J.W., W. Gray, D. Cobb, and T. Walker, 2013. A watershed analysis of permitted coastal wetland impacts and mitigation assessment methods within the Charlotte Harbor National Estuary Program. Florida Scientist, 76(2): 310–327.

Davies, S.P. and S.K. Jackson, 2006. The biological condition gradient: a descriptive model for interpreting change in aquatic ecosystems. Ecological Applications, 16(4): 1251-1266.

Fennessy, M.S., A.D. Jacobs, and M.E. Kentula, 2004. Review of Rapid Methods for Assessing Wetland Condition. EPA/620/R-04/009. U.S. Environmental Protection Agency, Washington, D.C.

O'Neil, P.E. and T.E. Shepard (GSA), 2012. Calibration of the Index Of Biotic Integrity For The Southern Plains Ichthyoregion in Alabama. Open-File Report 1210, Geological Survey of Alabama, Ecosystems Investigations Program. Tuscaloosa, AL.

The Nature Conservancy (TNC), 2009. Prioritization Guide for Coastal Habitat Protection and Restoration in Mobile and Baldwin Counties, Alabama. 37 pp.

Rosgen, D.L., 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, CO.

Shafer, D.J, T.H. Roberts, M.S. Peterson, and K. Schmid, 2007. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing the Functions of Tidal Fringe Wetlands Along the Mississippi and Alabama Gulf Coast. U.S. Army Corps of Engineers, Engineer Research and Development Center, Vicksburg, MS. 76 pp + appendices

Stout, J.P., K.L. Heck, Jr., J.F. Valentine, S.J. Dunn, and P.M. Spitzer, 1998. Preliminary Characterization Of Habitat Loss: Mobile Bay National Estuary Program. MESC Contribution Number 301. 183 pp.

Attachment 1 – Biological Indicator Review

Introduction

The Mobile Bay National Estuary Program (MBNEP) is identifying environmental indicators that will be used to gauge progress toward the objectives established in the MBNEP Comprehensive Conservation Management Plan. The intent of the MBNEP is to calibrate a Biological Condition Gradient (BCG) model to the Mobile Estuary. The BCG is a conceptual model that can be adapted and applied to specific regions or estuaries. A BCG model is a tiered system of aquatic life use designation along a gradient that describes how ten biological attributes change in response to increasing levels of human disturbance. A BCG approach for the MBNEP would provide a method of ecosystem assessment using biological information as a means to measure the status and trends of habitat quality.

For estuarine BCG, ten biological attributes are contained within five categories:

"Structure"

1. Historically documented, sensitive, long-lived or regionally endemic taxa
2. Sensitive and rare taxa
3. Sensitive but ubiquitous taxa
4. Taxa of intermediate tolerance
5. Tolerant taxa

"Non-native"

6. Non-native taxa

"Condition"

7. Organism condition

"Function"

8. Ecosystem functions

"Connectivity"

9. Spatial and temporal extent of detrimental effects
10. Ecosystem connectance

Each of the five Attribute categories may be applied to a single habitat, or to a mosaic of habitats that comprise the estuary as a whole. Attributes are then assigned a level of condition based on the amount of anthropogenic stress or change from the natural condition. The gradient represented by the BCG to describe the ecological state of the attributes is divided into 6 tiers or levels of condition, ranging from a natural/native condition (1) to severe changes in the structure of the biotic community and major loss of ecosystem function (6).

The MBNEP has reviewed and evaluated potential indicators to identify those that could be recommended as supporting BCG and biological monitoring of the estuary condition. Existing biological and physical environmental data, including data from previous studies and monitoring programs in the MBNEP study area, are being examined to determine if they are adequate to apply to the BCG. Identified resources consisting of one or more habitat types or other biological indicators will be assigned to the five estuarine Attribute categories. Identification of natural conditions would set a goal for restoration of degraded habitats within the MBNEP study area.

Indicator Review

As part of the indicator development process, the MBNEP solicited input from stakeholders, including the general public, local officials and scientists, and other experts in methods of environmental assessment. The public was invited in 2004 to participate in an online survey of attitudes and perceptions of the environment in the MBNEP study area. An analysis of the survey results was presented in an Online Survey Indicators Report (Battelle, November 2004). Subsequent to the online survey, an Indicators Workshop was held in Mobile in February 2005, bringing together local citizens and environmental professionals from federal and state agencies, universities, and non-profit organizations.

The Online Survey Indicators Report and the Executive Summary for the Indicators Workshop were reviewed to assess prior public and stakeholder input into the identification of environmental indicators of interest in the MBNEP study area, with a focus on those which could be applied to a BCG model approach. The online survey report assessed participant responses in terms of their relevance to potential indicators in five categories, which were also the focus of the indicator workshop, including:

Water Quality
Habitat Management
Living Resources
Human Uses
Education/Public Involvement

A BCG model assesses the status of ecological attributes, and therefore review of the online survey and indicator workshop results focused primarily on biological indicators in the first three categories. Indicators of interest are those metrics with potential for application to a BCG model approach that assesses environmental status and trends across the entire MBNEP study area. To be considered, potential BCG indicators must meet two basic requirements:

I. The indicator must be applicable to estuary BCG, either for a single habitat or for a habitat mosaic approach.

II. The indicator must be practicable for use in a MBNEP monitoring program assessing estuary-wide status and trends.

The following sections present a brief review of the 2004 Online Survey Indicators Report and the Executive Summary for the 2005 Indicators Workshop. Potential indicators are discussed based on applicability to a BCG approach and practicability for a MBNEP monitoring program.

<u>2004 Online Survey Report</u>

The online survey report developed potential environmental indicators based in part on the survey results. The report states that subjective methods were used to compile the respondents' input in developing the potential indicators.

Table 1 presents the water quality (WQ) indicators derived from the online survey. Many of the WQ indicators are not biological metrics, and cannot be assessed within a BCG framework. These indicators include numbers of stormwater upgrades and permitted outfalls, the number of beach closure days, various hydrologic parameters, and area closed to fishing. Indicators such as bacteria/pathogens load and fecal coliform counts are biological metrics, but within a BCG framework represent stressors that would affect natural community indicators.

Table 1. Water quality (WQ) indicators derived from the 2004 online survey.

WQ indicators not applicable to BCG	WQ indicators potentially applicable to an estuarine BCG model
Percent open space	Species abundance over time (A, B)
Number of stormwater upgrades	Bioaccumulation (A)
Number of permitted outfalls	Loss of beach/year (B)
Freshwater inflow	Fish tissue toxics data (A)
Toxics (PCBs, mercury, pesticides)	Chlorophyll *a* (A)
Number of beach closure days	Seagrass nutrient pollution index (A)
Nutrient loads	Incidence of disease for fish/shellfish (A)
Sediment loads	Level of contaminants in representative shellfish and at-risk humans (A)
Number of commercial fishing licenses	
Temperature & salinity	
Dissolved oxygen	
Fish consumption advisories	
Area of shellfish bed closure by year	
Area closed to fishing	
Number of recreational fish landings	
Bacteria/pathogens load	
Fecal coliform counts at oyster growing sites over time	
Fecal coliform counts at recreational sites over time	
	A = single habitat; B = habitat mosaic

Of the identified WQ indicators that are potentially applicable to an estuary BCG approach, most are not practicable for use in a monitoring program assessing status and trends across the entire study area. Programs assessing tissue toxins and contaminant levels are costly, and toxin sources may not be apparent, particularly in motile populations that may originate or venture outside the study area. Bioaccumulation studies are also cost-intensive and complicated in their analyses. Moreover, detectable bioaccumulation often has no apparent effect on the functioning of natural communities.

Chlorophyll *a* is useful as an indicator for detecting nutrient loading, which may cause water quality degradation and harmful algal blooms. Background or natural levels in the study area are largely unknown, however, which would be problematic when assessing degrees of degradation from natural levels, which is the basis of the BCG approach.

Of the potential WQ indicators, “Species abundance over time” appears to have the greatest potential for use in a BCG model framework, either for a single habitat or a habitat mosaic approach. The provenance of this indicator is unknown, since it was not included in the WQ survey questions.

“Loss of beach/year” or some metric related to beach habitat has potential as an indicator in a habitat mosaic approach. The most-often cited method of “contact with coastal waters” of survey respondents was at the beach (89%), and a strong majority of responses to the issue of beach erosion were very concerned (55%) or concerned (31.7%), though beach erosion is more an issue of habitat loss than of water quality.

Table 2 presents the habitat management (HM) indicators derived from the online survey results. As with the potential WQ indicators, some of the HM indicators are not applicable to BCG (e.g., water transparency).

The specific aspect(s) of "Native species diversity" as an indicator is not explicit in the wording of the survey question regarding diversity (Question 9), nor is the reasoning behind the formulation of the indicator explicitly informed by the survey responses. A majority of respondents (74.7%) rated the plant and animal communities of the Mobile Bay estuary as diverse (41.5%) or very diverse (33.2%). Within a BCG framework, "Native species diversity" would be assessed as changes through time compared with an established baseline condition. Use of this indicator for any specific species or guild would effectively be the same as use of the WQ indicator "Species abundance over time".

Table 2. Habitat management (HM) indicators derived from the 2004 online survey.

HM indicators not applicable to BCG	HM indicators potentially applicable to an estuarine BCG model
Water transparency	Native species diversity (A, B)
Sediment transport	Changes in habitat and species diversity (B)
Percent open space	Coastal wetlands (A, B)
Area and percent designated for permanent habitat protection	Changes in land-water ratios (A, B)
	Reclaimed habitat (A, B)
	A = single habitat; B = habitat mosaic

The indicator "Changes in habitat and species diversity" may be more appropriately expressed as "Changes in habitat diversity", to distinguish it from the "Native species diversity" indicator. This indicator could be addressed though a habitat mosaic BCG approach. Diversity measures generally are related to the relative proportions of a set of different biotic components.

Survey respondents viewed wetlands as an important habitat. Majorities of respondents indicated that wetlands were either "insufficient" to support, or needed increased conservation with regard to, migratory birds (19% and 46%, respectively), removal of excess nutrients (28% and 49%), and threatened species (19% and 50%).

The HM indicators derived from the online survey are potentially applicable to a BCG model, either for individual habitats or the habitat mosaic approach. Majorities of respondents believed that there are insufficient amounts, and need for increased conservation, of wetlands, oyster reefs, and seagrass beds. A large majority (93.2%) responded that restoration of sensitive habitats throughout Alabama's coastal waters was either very important (60.6%) or important (32.6%). Restoration of various critical habitats would be addressed in a restoring habitat balance BCG approach.

Table 3 presents the living resources (LR) indicators derived from the online survey results. The "Number of fish and wildlife species" indicator was not explicitly included in the LR survey questions. Depending on the particular biotype or ecological guild of interest for BCG, this indicator may be interchangeable with the WQ "Species abundance over time" and HM "Native species diversity" indicators.

Table 3. Living resources (LR) indicators derived from the 2004 online survey.	
LR indicators not applicable to BCG	LR indicators potentially applicable to an estuarine BCG model
Costs of invasive species control	Number of fish and wildlife species (A, B)
Number of annual fishing licenses (commercial and recreational)	Presence or absence of unique habitats (A, B)
Number of shellfish licenses (annual)	Change in the number of acres of wetlands affected by invasive, non-native species (A)
Commercial and recreational fishing economic value	Shrimp abundance over time (A, B)
	Oyster abundance on public seed grounds over time (A)
	A = single habitat; B = habitat mosaic

The methodology used to identify "Presence or absence of unique habitats" as a potential LR indicator is unknown. The LR survey questions did not include the topic. Similarly, though respondents were asked to provide a level of concern for the potential threat of particular invasive species, mostly animals, the reasoning behind the formulation of the indicator "Change in the number of acres of wetlands affected by invasive, non-native species" is unknown. Nevertheless, these two indicators have potential as metrics in a habitat mosaic-based BCG approach.

The LR fauna identified in Table 3 are not practicable as status and trends indicators. Shrimp and oyster populations are managed by state agencies, and it is unlikely that a direct effort conducted through a MBNEP monitoring program would add value to those existing, routine assessments, unless additional data were collected to document spatial and temporal patterns.

Of the question addressing levels of concern for sustaining populations of inshore commercial species (Question 17), respondents were "very concerned" about shrimp (76%), blue crab (74%), and oyster (73%), though blue crab was not included as a potential indicator in the survey report. Likewise, for the question regarding sustaining inshore game species (Question 16), the species of greatest concern (flounder, redfish, speckled trout) were not identified as potential indicators. For all species of concern identified by survey respondents, incorporation into a BCG model would be most effective using indirect consideration through monitoring of changes in the areal extent of their critical habitats. The survey responses are potentially useful in the development of key faunal guilds, as a means to identify their critical habitats that could be assessed in a restoring habitat balance approach.

<u>2005 Indicators Workshop</u>

The MBNEP Indicators Workshop held in 2005 was constrained by a mandate that indicators considered would be limited to those supported by datasets produced under (then) existing monitoring efforts. The workshop results therefore are not necessarily comprehensive with respect to indicators potentially usable within a BCG framework. They do nonetheless represent a consensus view of those environmental indicators most representative of a healthy estuarine ecosystem.

Table 4 presents the WQ indicators identified during the workshop. Because they are not biological metrics, many of the potential indicators developed by the workshop would not be applicable to a BCG model, even though to some degree they could affect floral and faunal populations.

Table 4. Water quality (WQ) indicators identified during the 2005 Indicator Workshop.	
WQ indicators not applicable to BCG	WQ indicators potentially applicable to an estuarine BCG model
Dissolved oxygen	Harmful algal blooms (A)
Light attenuation	Chlorophyll *a* (A)
Secchi depth	Tissue chemistry – fish and shellfish (A)
Sediment chemistry	Enterococcus monitoring (A)
Atmospheric mercury	Fecal coliform (A)
Loadings (TRI, NPDES)	
Potentially Important	*Potentially Important*
Suspended sediments	Macroalgal biomass/benthic productivity (A, B)
Temperature	
Salinity	
	A = single habitat; B = habitat mosaic

As with the identified WQ indicators derived from the online survey results, and which are potentially applicable to an estuary BCG approach, most of the indicators identified at the workshop are not practicable for use in a monitoring program assessing status and trends across the entire study area. The indicator "Macroalgal biomass/benthic productivity" appears to have the greatest potential for use in a BCG model framework, either for a single habitat or a habitat mosaic approach.

Table 5 presents the HM indicators identified during the workshop. HM indicators usable within a BCG model framework are those that would be addressed through a habitat balance approach -- acres of habitat by type, changes and trends, and acres protected and restored.

Though most of the potential HM indicators could be used in both the single habitat and habitat mosaic approaches, the latter approach would be most useful as a status and trends assessment program for the entire estuary. HM indicators usable within a BCG model framework are those that would be addressed through a restoring habitat balance approach, including acres of habitat by type and acres protected and restored.

Table 5. Habitat management (HM) indicators identified during the 2005 Indicator Workshop.	
HM indicators not applicable to BCG	HM indicators potentially applicable to an estuarine BCG model
Pollution trends	Acres of habitat quantity by type (B)
	Acres of habitat protected or restored (A, B)
	Shoreline/riparian change trends (A, B)
	Hydrologic/bathymetric change (A, B)
	Land use, cover changes, and trends (A, B)
	A = single habitat; B = habitat mosaic

Table 6 presents the LR indicators identified during the workshop.

Table 6. Living resources (LR) indicators identified during the 2005 Indicator Workshop.

LR indicators not applicable to BCG	LR indicators potentially applicable to an estuarine BCG model
Number of threatened/endangered species	Biodiversity of bottom-dwelling species: blue crabs, oysters, flounder (A, B)
Number of species on special concern list	Biodiversity of mid-water species: largemouth bass, red drum, mullet, and other forage (A, B)
	Biodiversity of birds: pelicans, waterfowl, neotropical migrants (A, B)
	Number of ospreys and eagles (A, B)
	Acreage of non-native macrophytes (A, B)
	Frequency of occurrence of non-native species (A)
	Occurrence of non-native crabs (A)
Future Study	*Consider for Future Study/Monitoring*
Distribution of coarse and soft bottoms	Diversity and composition of riparian insect assemblages (A, B)
	Number of listed species relative to year (x) and related habitat acreage (A, B)
	Crawfish
	Alligators
	Tadpoles
	Gulf sturgeon
	Diamond back terrapin
	Alabama red-bellied turtle
	Nutria

A = single habitat; B = habitat mosaic

Many of the identified LR indicators are monitored under existing federal and state programs, including federal- and state-listed species of concern, various birds, and certain fishery resources. Biodiversity indicators were developed for ecological guilds, including bottom-dwelling species, mid-water species, and birds. Each indicator guild included three or four specific taxa or species categories, but it is unknown whether the indicators are intended to be restricted to those named components. There is increasing interest in use of biodiversity indices to assess environmental status and trends, and though the measures of biodiversity identified by stakeholders are important, their applicability to assessment of estuary-wide status and trends is not clearly defined. In addition, establishing a baseline condition would be problematic. Monitoring biodiversity at a guild or species level would entail large monetary costs and levels of effort.

The number of ospreys and eagles not appear practicable for use in a MBNEP monitoring program due to the levels of effort required to quantify the status of their populations. As with the biodiversity indicators, their applicability to assessment of estuary-wide status and trends is not apparent. Many of the identified LR indicators may be valuable for use in developing key faunal guilds, as a means to identify critical habitat types that could be assessed in a habitat mosaic BCG model approach.

"Acreage of non-native macrophytes" presumably refers to SAV, though it may also refer to algae. If used as a metric in a BCG model, to be useful it should be included with other biological indicators, such as overall SAV acreage. By itself the indicator does not seem to be suitable for use in comprehensive assessment of estuary-wide status and trends. This is also the case with the indicators "Frequency of occurrence of non-native species" and "Occurrence of non-native crabs".

Table 7 presents the HU indicators identified during the workshop. The HU indicators potentially applicable to an estuarine BCG model are habitat-based, including those related to wetlands, natural shorelines, and land use changes. The meaning of the indicator "Percentage of shellfishing" is unknown. It might refer to the percentage of total oyster reef acreage open to harvest.

Table 7. Human Uses (HU) indicators identified during the 2005 Indicator Workshop.

HU indicators not applicable to BCG	HU indicators potentially applicable to an estuarine BCG model
Human population growth/changes	Functional wetland – protected, restored, enhanced, and created (A, B)
Municipal wastewater permit violations	Number and percentage of shorelines hardened – bulkheading (A, B)
Number of 303(d)-listed streams	Acreage of land converted to alternate use (B)
Number and types of development permits	
Impervious surfaces	
New road construction	
Future consideration	*Future consideration*
Best management practices activity	Percentage of shellfishing (A)
Quality, quantity, and identification of outfalls	
Boat ramps and access sites – linear feet and availability	
	A = single habitat; B = habitat mosaic

Indicator Development Conclusions

Many of the potential indicators presented in the online survey report and identified at the indicators workshop would not be applicable to a BCG model. Of those water quality indicators usable in a BCG approach, most would not be practicable for use in a MBNEP status and trends monitoring program assessing the entire estuary. For a single habitat approach assessing soft sediments, which constitute most of the study area, some measure of benthic productivity would serve as the best status and trends indicator estuary-wide.

Habitat was a primary concern among the online survey respondents and workshop participants, including restoration of altered habitats. Several indicators considered in both the online survey and workshop would be addressed a habitat mosaic BCG approach.

Species diversity was another indicator of interest, but there is no consensus regarding the community constituents, ecological guilds, or individual species that should be monitored. As a practical matter of survey logistics, costs, and design, a monitoring program would have to focus on particular species or groups of species that would be indicative of the overall estuary condition at any point in time. And establishing a baseline for comparison with future monitoring, which is a basic requirement of the BCG approach, would be difficult.

Any biodiversity monitoring should focus on ecosystem components that have relevance to water quality, habitat management, or both (e.g., brackish marsh). Because of monetary costs and survey design constraints, using one or more biodiversity indicators at a population level does not appear to be practicable. At a landscape level, biodiversity attributes could include the distribution and proportions of a number different habitats or biotopes, which could serve as proxies for the species depending on and occurring within those habitats.

Development of a Conceptual Model of a Mobile Bay Regional BCG

The first technical component of calibrating a regional BCG is to adjust the generalized conceptual model to local conditions. Calibrating the BCG model to the MBNEP study area broadly includes three components that together construct a coherent ecological description of biological response to natural and anthropogenic stressors:

1. A description of the native aquatic assemblages under natural, undisturbed conditions, to provide a baseline with which to compare and assess the condition of estuary waterbodies.

2. Identification and description of regional stressors to help define expectations for biological responses likely to occur.

3. A description of the BCG. The conceptual model of the BCG may require some example data from sites to empirically validate conclusions.

A critical aspect of Mobile Bay BCG model development will be identification of Tier 1 baseline conditions, which could be represented by a historic state, by present-day, specific locations determined to be in a natural condition, or a combination of both.

Potential BCG Approaches for the Mobile Bay Estuary

For any approach to developing a BCG Model for the MBNEP, its feasibility will be a function of the amount and quality of available data for relevant biological components, and how the data can be used in a quantitative approach that provides meaningful descriptions of environmental quality. Potential BCG approaches initially considered include restoring the historic balance among acreages of various habitat types, and monitoring of benthic habitat communities as indicators of sediment and water quality.

<u>Restoring Habitat Balance</u>

The Tampa Bay NEP has adopted a “restoring habitat balance” approach based on reestablishment of the relative proportion of habitat types (SAV, mangrove, tidal marsh, salt barren) that existed “pre-development”. In the restoring balance approach, habitats are proxies for key faunal guilds of estuarine-dependent species. To adopt a restoring balance approach, the historic extent of significant habitat types must be determined for the MBNEP study area to establish a baseline condition for incorporation into the BCG model.

Primary Advantages

- A historic SAV acreage baseline is completed for a portion of the MBNEP study area (BVA, 2005), in addition to coastal wetland (NWI) acreage (Roach et al, 1987), and the extent of natural shorelines in Mobile Bay (Douglas, 1997).
- Mapping can be performed largely on computer with periodic aerial imagery acquisition and relatively minor field validation effort; logistical issues and costs associated with large, routine faunal sampling efforts are avoided.
- Restoration activities and approaches undertaken based on habitat balance assessments would be focused on those habitat types that historically have been most disproportionately lost or degraded.

Key Hurdles

- A GIS database will have to be established for baseline "pre-development" conditions of coastal marshes and other habitats of interest.
- GIS coverage of a historic SAV acreage baseline does not currently include the delta and Dauphin Island areas.
- SAV occurrence in the study area varies naturally, often significantly, on an interannual basis; is it feasible to attempt to achieve a historic "balance" of habitats that includes SAV?
- There may be limited locations in the study area that are available and suitable for restoration of SAV, tidal marsh, and other habitat types.
- Restoration of historic habitat balance may not account for environmental degradation in locations that do not contain the habitats of interest.

<u>Benthic Habitat Monitoring</u>

Greenwich Bay (RI), part of the Narragansett NEP study area, is investigating the feasibility of a BCG approach based on benthic macroinvertebrates as indicators of sediment and water quality. Benthic community assessment potentially represents a useful approach due to the sedentary nature of benthic infauna and role their in ecosystem function.

Primary Advantages

- The MBNEP study area consists mostly of unconsolidated, non-structured sediments.
- Monitoring benthic community composition is a well-established method of assessing biotic integrity, with assemblage composition largely reflective of sediment and water quality.

- The State of Alabama conducts estuarine benthic monitoring that may be complementary to a MBNEP monitoring program, with potential for program coordination.

Key Hurdles

- To calibrate a BGC model to the Mobile estuary focused on soft sediment macroinvertebrate assemblages, it is likely that comprehensive benthic studies will first have to be conducted to adequately define a baseline of natural community composition for the range of sediment habitats in the study area.

- Regional stressors have been largely defined for broad habitat effects, such as with dredging and hypoxia, but some stressor effects, such as sediment contamination influences, are poorly understood and may not be detectable.

- Monetary costs of baseline and permanent field monitoring programs could be substantial.

Attachment 2 – Environmental History of Coastal Alabama

Major environmental alterations of the MBNEP study area have occurred historically. Human habitation of Alabama stems from 10,000 to 12,000 years before present (BP), and evidence from the Mobile-Tensaw Delta goes back at least 5,000 years BP. Archaic stage inhabitants of coastal Alabama hunted and fished, and harvested oysters. Beginning around 3,000 BP, Woodland Period inhabitants led a more sedentary life compared to the Archaic Stage, with horticulture increasing in importance. Mississippian Period inhabitants had an estuary-oriented economy, adapted to the exigencies of deltaic horticulture, with seasonal hunting adjusted to delta flooding.

Europeans first came to Alabama in the 16th century. In 1711 the City of Mobile was moved to its present-day location at the confluence of the Mobile River and Mobile Bay. Numerous farms and plantations were located throughout in the delta by the late 1700s, with extensive areas along riverbanks cut and cleared of timber. Corn, rice, and indigo were cultivated and cattle grazed in these areas. Logging bald cypress began soon after French settlement in the early 1700s, and by the 1920s the original cypress resource was nearly exhausted. By the late 19th century the long-leaf pine forests were the main timber source at sawmills in coastal Alabama. The cutover pinelands of Mobile and Baldwin Counties were increasingly converted to farms and developed during this time.

A significant proportion of the original wetlands of coastal Alabama have been filled and altered. The City of Mobile was built on land reclaimed from the Mobile River and adjacent wetlands during three successive fill episodes -- 1815 to 1824, 1824 to 1838, and during the 1890s. In 1725, Fort Conde was directly on the edge of Mobile River wetlands, but by 1815 newly reclaimed land had increased the distance between the fort and the Mobile River. Between 1815 and 1838, an additional two city blocks had been added by filling riverfront water and wetlands.

From the mid-1800s to the mid-1900s, new land was created from dredged material in Mobile Harbor, forming Blakely Island, Pinto Island, Garrows Bend, McDuffie Island, Arlington Pier, and Little Sand Island. In 1918, Tennessee Coal and Iron Co. constructed a shipyard at what would become the City of Chickasaw, constructing dikes and draining the cypress swamp adjacent to Chickasaw Creek. The Alabama State Docks opened in 1928, built on over 500 acres of swampland and marsh.

Between 1953 and 1968 approximately 2,152 acres of Mobile estuary were filled above MLW (Crance, 1971). By one estimate (Handley et al., 2002), between 1955 and 2002 coastal Alabama emergent palustrine and estuarine wetlands declined by 23,647 and 12,820 acres, respectively. Roach et al. (1987) estimated that between 1955 and 1979 the acreage of coastal Alabama fresh marshes and estuarine marshes declined by 69% and 29%, respectively, with 48% of the decline attributed directly to human activity. Between 1955 and 2001-2002, urban land cover in the Alabama coastal area increased by 128 mi^2 (Handley et al., 2002).

In 1826, the first Federal dredging project was authorized for Mobile Harbor between Choctaw Point Spit and Dog River Bar, and dredged to 10-ft depth. From the late 19th century until 1980, open water placement of dredged material along the Mobile Bay Channel modified circulation patterns and exacerbated episodes of low dissolved oxygen. The main navigation channel from the Gulf to Mobile increased to 13-ft depth in 1870. In 1888, the main channel was increased to

23-ft deep and was extended north to Chickasaw Creek. By the late 1930s the main channel depth increased to 30 ft. By the 1960s an estimated average of 1.4 million tons of sediment bypassed the bay annually due to the main ship channel.

Land removal has also modified the Alabama estuarine environment. In 1934, the Gulf Intracoastal Waterway was completed between Pensacola Bay and Mobile Bay, including 7 miles of land cut through southern Baldwin County. In 1979 the Theodore Ship Channel was constructed by dredging a deep draft ship channel about 5.2 miles long, 400-ft wide and 40-ft deep, linking the Mobile Ship Channel with the Middle Fork of Deer River. Dredged material from the Theodore Channel was used to create the 1,700-acre Gaillard Island in middle Mobile Bay.

Natural river flow and hydrology of the Mobile Bay watershed and estuary has been significantly altered. By the 1880s, Barge traffic upriver was made possible by a series of locks and dams, extending the upriver limit of vessel traffic from Mobile Bay. Beginning in the early 20th century dozens of dams were constructed throughout the Mobile River Basin, mostly for upstream flood-control, reservoirs, and hydroelectric generation. Construction of the 234-mile Tennessee-Tombigbee Waterway in 1984, upstream of Mobile Bay, included ten locks and dams forming 42,400 acres of lakes. The 7-mile Mobile Causeway is a land bridge that was built in 1927 across upper Mobile Bay and the lower Mobile-Tensaw delta, and has since impeded hydrologic exchange at Chocolatta Bay, Justin's Bay, Sardine Pass, and Shellbank River.

Through the years, Mobile Bay has absorbed significant quantities of heavy metals derived from various industrial and municipal sources. At least five major coastal Alabama shipyards supplied vessels in support of WWI. Shipbuilding was supplanted as a dominant industry after World War II by expansion of paper and chemical industries. There were 31 industries discharging effluents into coastal Alabama waters by the 1960s, with 16 of these sources collectively averaging 801.7 million GPD. At the same time there were 23 sources of domestic wastewater pollution entering Alabama streams and estuaries.

Year	Duration	Data	Quantitative	Qualitative	Reference
	7,000 to 6,000 years before present	Geology	Mobile Bay was a marsh-covered floodplain, Mississippi Sound a forest-covered floodplain; deltaic system extended out onto the present-day GOM shelf.		Hummell and Parker, 1995a; 1995b
		Geology	Low-gradient paleovalleys on the MS-AL inner continental shelf were inundated by sea level rise, with rapid rates of transgression.		Greene et al., 2007
	10,000 to 3,500 YBP	Historic		Archaic stage people hunted, fished, and harvested oysters; evidence of human habitation in the Mobile-Tensaw Delta dates to 5,000 years BP.	May, 1971 Encyclopedia of Alabama, accessed 10-12-2012
	4,000 YBP	Geology	Mobile Bay attained its present configuration, water circulation patterns, and sediment facies distribution.		Hummell and Parker, 1995a
	3,000 to 450 YBP	Historic		Woodland Period inhabitants with a more sedentary life compared to Archaic Stage; Mississippian Period had an estuary-oriented economy, adjusted to deltaic flooding.	Knight, 1984 Walthall, 1980 Morgan, 2003 Curren, 1978

1519		Historic		Alonzo Alvarez de Pineda the first Spanish explorer to reach Alabama	Summersell, 1957
1711		Historic		City of Mobile was moved to its present-day location at the confluence of the Mobile River and Mobile Bay.	Crance, 1971
18th Century	- Early 20th Century	Historic		Logging bald cypress began soon after early 1700s French settlement.	Mohr, 1878 Mancil, 1980
1734		Historic		Fort Conde wharf built directly on the edge of Mobile River wetlands	New South Associates, 1991
	Early to late 18th Century	Historic		Numerous farms and plantations in the MTD; extensive areas along riverbanks cut and cleared of timber.	Romans, 1962 Harper, 1958 Crown Collection of Photographs of American Maps, 1915
	Late 18th Century	Historic		Invasive Chinese tallow tree first introduced to the Southeastern U.S.	Bell, 1966
1802		Historic		Panton, Leslie and Company filled the shallow lagoon along the Mobile river in front of their Royal Street offices and built a commercial wharf.	Irion, 1990 Gould, 1988
	19th Century	Wetlands		Mobile waterfront built on reclaimed land during three successive fill episodes -- 1815 to 1824, 1824 to 1838, and during the 1890s.	New South Associates, 1991

	19th Century	Land use	The number of wharves along the Mobile waterfront grew from two in 1815, to 14 in 1824, to 46 in 1838.		New South Associates, 1991
1819		Historic		Alabama granted statehood	
1822		Historic		Mobile population 2,800	Thomason, 2001
1826	- Mid-19th Century	Dredging		First Federal project authorized for Mobile Harbor between Choctaw Point Spit and Dog River Bar, at 10-ft dredged depth.	Panamerican Consultants, 2001
1828		Dredging		First Federal project authorized to dredge channel between Mobile Bay and Mississippi Sound (Pass au Heron).	USACE, 1983
1849/50	- 1957		In Mobile Harbor, new land was created from dredged material, including Blakely Island. Pinto Island, Garrows Bend, McDuffie Island, Arlington Pier, and Little Sand Island.		Byrnes et al., 2012
1860		Historic		Mobile's population within the city limits at 29,258 people, comprising the 27th largest city in the U.S.	Thomason, 2001
1870		Dredging		Main channel from the Gulf to Mobile increased to 13-ft depth	Weber, 1968

	1880s to present	Hydrology		Barge traffic upriver from Mobile Bay made possible by a series of locks and dams.	Panamerican Consultants, 2001
1888	- Early 20th Century	Dredging		Main channel from the Gulf increased to 23-ft deep and extended north to Chickasaw Creek.	Panamerican Consultants, 2001
Late 19th Century		Water quality, Sediments	Channel dredging and spoil disposal in Mobile Bay altered circulation and reduced estuarine mixing.		Osterman and Smith, 2012
1894		Oysters	The first attempt to accurately map oyster reefs documented 3,103 acres.		Ritter, 1896
1911	- present	Hydrology	36 dams were constructed throughout the Mobile River Basin, for reservoirs, hydroelectric generation, and flood-control.		Johnson et al., 2002; Atkins et al., 2004
	Late 19th Century	Land Use		Long-leaf pine forests were the main timber source at sawmills in coastal Alabama; cypress resource nearly exhausted.	Mohr, 1901
1913		Land use		Cutover pinelands of Mobile and Baldwin Counties increasingly converted to farms.	Harper, 1913
1913		Shellfish	Continuous oyster reef from Buoy Reef to Pass Drury totaling 3,900		Moore, 1913

			acres.		
	1900 to 1920	Land Use	Mobile's population increased from 40,000 to 60,000.		
1917		Land Use		Five major coastal Alabama shipyards supplied vessels in support of WWI.	Mistovich and Knight, 1983
1918		Wetlands		Tennessee Coal and Iron Co. constructed a shipyard at what would become the City of Chickasaw, diking and draining a cypress swamp on Chickasaw Creek.	City of Chickasaw website, accessed 2014
1927	- present	Water quality		Highway 90 Causeway was built across the lower Mobile-Tensaw delta, impeding hydrologic exchange at Chocolotta Bay, Justin's Bay, Sardine Pass, and Shellbank River.	
1928		Wetlands	Alabama State Docks built on 500 acres of swampland and marsh.		
1928		Historic		Little of the original deltaic cypress forest remained.	Harper, 1943
1934		Dredging, Land Use		Intracoastal waterway GICWW completed between Pensacola Bay and Mobile Bay, including a 7-mile land cut.	USACE, 1983
	Late 1930s	Dredging		Mobile Bay main navigation channel	

				depth increased to 30 ft.	
	1940s to 1970s	Historic		Paper/chemical industries expanded in coastal area, supplanting shipbuilding industry.	May, 1971
1947		SAV		Pondweeds, horned pondweed, wild celery, and southern naiad abundant in the bays of the lower MTD.	Lueth, 1963
1949		Historic		Nutria (Myocastor coypus) introduced into the delta by the AL Dept of Conservation for use as weed control agents	Lueth, 1963
1952		Water quality	Oyster beds in lower Mobile Bay closed due to high bacterial concentrations.		Alabama Water Improvement Commission, 1967
1957		SAV	5,000 acres of SAV in Mobile Bay and 7,500 acres in the lower delta		Baldwin, 1957
	1953 to 1968	Wetlands	Approximately 2,152 acres of Mobile estuary filled above MLW.		Chapman, 1968
	1955 to 1979	Wetlands	Coastal Alabama fresh marshes and estuarine marshes acreage declined by 69% and 29%, respectively; 48% attributed directly to human activity.		Roach et al., 1987
1955	-2001/02	Wetlands	Coastal Alabama emergent palustrine		NWRC, 2007

			wetlands and estuarine wetlands declined by 23,647 and 12,820 acres, respectively.		
1955	-2001/02	Land use	Alabama coastal zone urban cover increased by 82,011 acres (128.14 mi^2).		NWRC, 2007
	2002	SAV	Mobile County SAV acreage in 2002 was 44.5% of the acreage in 1940; 691 fewer acres along the western shore of Mobile Bay and 268 fewer acres in Mississippi Sound.		Barry A. Vittor & Associates, Inc., 2005
	2002	SAV	Baldwin County SAV acreage in 2002 was 11.7% of the acreage in January 1955.		Barry A. Vittor & Associates, Inc., 2005
1960		Land use	There were approximately 500 private piers along the shoreline of Mobile Bay.		Crance, 1971
Late 19^{th} Century	- present	Dredging	Mobile Ship Channel modified natural circulation in the bay; above average rates of sediment accumulation occurred in SW Mobile Bay.		Ryan, 1969
Late 19^{th} Century	- present	Sediments	An estimated average of 1.4 million tons of sediment bypassed the bay annually due to main ship channel; deposited		Ryan, 1969

			primarily south and west of Mobile Pass.		
1971		Shellfish	3,064 acres of natural oyster reefs were mapped in Mobile Bay.		May, 1971
Late 19th Century	1980	Hypoxia	Open water placement of dredged material along the Mobile Bay Channel modified circulation patterns, exacerbated episodic low dissolved oxygen.		May, 1973
1970		Water quality	There were 23 sources of domestic pollution entering the estuaries and nearby contributory streams; Effluent from 19 of these sources averaged 25.6 million GPD.		Crance, 1971
	1960s	Water quality		The most significant contributor of bacterial pollution in Mobile Bay was the untreated section of the Mobile Metropolitan Area.	Gallagher et al., 1969
	1960s	Water quality		Water quality and marine life in Perdido Bay adversely affected by paper pulp and sewage pollution.	U.S. Department of the Interior, 1970
	1960s	Water quality	31 industries discharged effluent		Alabama Water Improvement

			into coastal waters; average effluent from 16 of these sources was 801.7 million GPD.		Commission, 1967; Gallagher et al., 1969
	Mid-20th century	Water quality		AL Public Health Department announced that fish from certain areas of the Mobile Delta contained levels of mercury due to industrial manufacture of chlorine.	Mobile Press Register, July 1, 1970
	1970s	SAV		SAV on the Eastern Shore was almost completely gone, compared to previous decades.	Borom, 1979
1967	- present	Land use		D'Olive watershed land use identified as the major cause of excessive sedimentation into D'Olive Bay.	Isphording, 1981
1980		SAV	Eurasian watermilfoil abundant in 75% of SAV beds in 15 of 22 delta bays surveyed.		Stout and Lelong, 1981; Stout et al., 1982
Early 20th Century	- present	Metals	Mobile Bay has absorbed significant quantities of heavy metals, derived from various sources.		Isphording, 1983
1979		Dredging	1,700 acres of Mobile Bay waterbottom filled to create Gaillard Island		
1979		Dredging	Theodore Ship Channel		

			construction dredged ~5.2-mi long, 400-ft wide, and 40-ft deep to link the main ship channel with the Middle Fork of Deer River, Mobile Co.		
	20th Century	SAV	Perdido Bay SAV acreage in 1992 decreased 74% compared to 1941.		Kirschenfeld et al., 2006
1984	- present	Hydrology	The 234-mile Tennessee-Tombigbee Waterway was constructed upstream of Mobile Bay, and included ten locks and dams to form 42,400 acres of impoundments.		Underwood and Imsand, 1985
1994		SAV		Eurasian watermilfoil was the most abundant species of SAV in the MTD.	Zolczynski and Shearer, 1997
Early-20th Century	- present	Water quality	Perdido Bay has reduced benthic production due to salinity stratification and hypoxia, a direct result of dredging and saltwater intrusion from the GOM.		FLDEP, 2012
Early-20th Century	- present	Sediments	The Mobile Bay Causeway has resulted in reduced sedimentation rates to the bay.		Fern et al., 2004
Mid-20th	- present	SAV	Eurasian watermifoil		Martin and Valentine, 2012

Century			proliferation in lower delta enhanced by the presence of the Mobile Causeway.		
Mid-20th Century	- present	Land use	An estimated 32.4 percent of Baldwin and Mobile county shorelines protected by hard armoring: 268 km (166.3 miles) with bulkhead; 75 km (46.8 miles) with rubble/riprap.		Jones and Tidwell, 2012

References Cited

Atkins, J.B., H. Zappia, J.L. Robinson, A.K. McPherson, R.S. Moreland, D.A. Harned, B.F. Johnston, and J.S. Harvill, 2004. Water Quality in the Mobile River Basin, Alabama, Georgia, Mississippi, and Tennessee, 1999-2001. Reston, Virginia: U.S. Geological Survey, Circular 1231, 36 pp.

Alabama Water Improvement Commission, 1967. Water Quality Standards for Waters of Alabama and a Plan For Implementation. 260 pp.

Baldwin, W.P., 1957. An inspection of waterfowl habitats in the Mobile Bay area. Alabama Department of Conservation. Special Report No. 2. 40 pp.

Barry A. Vittor & Associates, Inc., 2005. Historical SAV Distribution in the Mobile Bay National Estuary Program Area and Ranking Analysis of Potential SAV Restoration Sites. Prepared for the Mobile Bay National Estuary Program, Mobile, AL. 13 pp.

Bell, M.I., 1966. Some Notes and Reflections upon a Letter from Benjamin Franklin to Noble Wimberly Jones, October 7, 1772. Ashantilly Press, Darien, GA.

Borum, J.L., 1979. Submerged grassbed communities in Mobile Bay, Alabama. Pages 123-132 In: Loyacano, H.A., Jr. and J.P. Smith (Eds.), Symposium on the Natural Resources of the Mobile Bay Estuary, Alabama.

Byrnes, M.R., J.L. Berlinghoff, and S.F. Griffee, 2012. Sediment Dynamics in Mobile Bay, Alabama: Development of an Operational Sediment Budget. Draft Final Report prepared for Mobile Bay National Estuary Program. Applied Coastal Research and Engineering, Inc., Mashpee, MA. 80 pp.

Carlton, J., J.S. Brown, J.K. Summers, V.D. Engle, and P.E. Bourgeois, 1998. A Report of the Condition of the Estuaries of Alabama in 1993-1995: A Program in Progress. Alabama Department of Environmental Management, Mobile, AL. 19 pp,

Chapman, C., 1968. Channelization and spoiling in Gulf Coast and South Atlantic estuaries. Pp 93-106 In: Proceedings of the Marsh and Estuary Management Symposium, Louisiana State University, Division of Continuing Education.

Curren, C.B., Jr., 1978. The zooarchaeology of the D'Olive Creek site (1Ba196). Journal of Alabama Archaeology, 24(1): 33-51.

Crance, J.H., 1971. Description of Alabama estuarine areas- Cooperative Gulf of Mexico Estuarine Inventory. Alabama Marine Resources Bulletin, 6: 1-85.

Crown Collection of Photographs of American Maps, 1915. Field survey of the River Mobile and part of the Rivers Alabama and Tensaw, with the different settlements and lands marked thereon. Crown Collection of Photographs of American Maps Ser. 3, 2:93, Cat. No. 40.

Douglass, S. L. and B. H. Pickel, 1999. The tide doesn't go out anymore: the effect of bulk-heads on urban bay shorelines. Shore & Beach 67: 9–25.

Duke, T., and W.L. Kruczynski, 1992, Status and Trends of Emergent and Submerged Vegetated Habitats of Gulf of Mexico Coastal Waters, U.S.A.: U.S. Environmental Protection Agency 800-R-92-003, 161 pp.

Encyclopedia of Alabama http://www.encyclopediaofalabama.org/face/Article.jsp?id=h-3196

Fern, M., D. Haywick, and J. Sanders, 2004. Changes in water conditions and sedimentation rates associated with construction of the Mobile Bay Causeway. Final Report to Alabama Center for Estuarine Studies. 8 pp.

Florida Department of Environmental Protection (FLDEP), 2012. Site-Specific Information in Support of Establishing Numeric Nutrient Criteria for Perdido Bay. 74 pp + appendices.

Gallagher, T.P., F.J. Silva, L.W. Olinger, and R.A. Whatley, 1969. Pollution Affecting Shellfish Harvesting in Mobile Bay, Alabama. U.S. Department of the Interior, Federal Water Pollution Control Administration, Athens, GA. 46 pp.

Greene, D.L., A.B. Rodriguez, and J.B. Anderson, 2007. Seaward-Branching Coastal-Plain and Piedmont Incised-Valley Systems through multiple sea-level cycles: Late Quaternary examples from Mobile Bay and Mississippi Sound, USA. Journal of Sedimentary Research, 77: 139–158

Harper, F. 1958. The Travels of William Bartram. New Haven: Yale University Press. 727 pp.

Harper, R.M., 1913. Economic Botany of Alabama, Part 1. Volume 8 of Monograph (Geological Survey of Alabama). Brown Printing Company, Montgomery, AL.

Harper, R.M., 1943, Forests of Alabama. Alabama Geological Survey Monograph 10, 230 pp.

Hummell, R.L. and S.J. Parker, 1995a. Holocene Geologic History of Mobile Bay, Alabama. Geological Survey of Alabama Circular 186, 97 pp.

Hummell, R.L. and S.J. Parker, 1995b. Holocene Geologic History of Mississippi Sound, Alabama. Geological Survey of Alabama Circular 185, 91 pp.

Irion, J.B., 1990. Archaeological Investigations of the Confederate Obstructions, Mobile Harbor, Alabama. PhD. Dissertation, The University of Texas at Austin, TX.

Isphording, W.C., 1983. Chemistry and Partitioning of Heavy Metals in Mobile Bay, Alabama. Pages 184-200 In Tanner, W.F. (ed.), Near-Shore Sedimentology. Proceedings of the Sixth Symposium on Coastal Sedimentology. Florida State University, Tallahassee, FL.

Isphording, W.C., 1981. Sedimentological Study of D'Olive Bay and Its Drainage Basin, Baldwin County, Alabama. Final Report. Contract No. DAC01-80-C0305. U.S. Army Corps of Engineers, Mobile, Alabama.

Jones, S.C. and D.K. Tidwell, 2012. Comprehensive shoreline mapping, Baldwin and Mobile Counties, Alabama: Phase III: Alabama Geological Survey, Open-File Report 1204, 112 pp.

Johnson, G.C, R.E. Kidd, C.A. Journey, H. Zappia, and J.B. Atkins, 2002. Environmental Setting and Water-Quality Issues of the Mobile River Basin, Alabama, Georgia, Mississippi, and Tennessee. Montgomery, Alabama: U.S. Geological Survey, National Water-Quality Assessment Program, Water- Resources Investigations Report 02-4162, 62pp.

Kirschenfeld, T., R.K. Turpin, and L.R. Handley, 2006. Perdido Bay, pp 115-127 In Seagrass Status and Trends in the Northern Gulf of Mexico: 1940-2002. U.S. Geological Survey Report 2006-5287.

Knight, V.J., Jr., 1984. Late prehistoric adaptation in the Mobile Bay region. Chapter 8 (pp 198-215) In Davis, D.D. (Ed), Perspectives on Gulf Coast Prehistory. University of Florida Press, Gainesville.

Lueth, F.X., 1963. Final Report of Pittman-Roberston Project 7-R Mobile Delta Waterfowl and Muskrat Research. Alabama Department of Conservation. Pittman-Roberston Project 7-R, Final Report, 86 p.

Livingston, R.J., 2010. Long-term (1988–2007) response of trophic organization of an estuary (Perdido Bay) to physical alterations and plankton blooms: Cumulative impacts and food web resilience. Nutrient report for the Florida Department of Environmental Protection.

Mancil, E., 1980. Pullboat logging. Journal of Forest History, 24:135-141.

Martin, C.W. and J.F. Valentine, 2012. Eurasian milfoil invasion in estuaries: physical disturbance can reduce the proliferation of an aquatic nuisance species. Marine Ecology Progress Series, 449:109-119.

May, E.B., 1971. A survey of the oyster and oyster shell resources of Alabama. Alabama. Marine Resources Bulletin, 4:1-53.

May, E.B., 1973. Extensive Oxygen Depletion in Mobile Bay, Alabama. Limnology and Oceanography, 18: 353-366.

Mistovich, T.S. and V.J. Knight, Jr. 1983. Cultural Resources Survey of Mobile Harbor, Alabama. 179 pp.

Mohr, C., 1901. Plant life of Alabama: an account of the distribution, modes of association, and adaptations of the flora of Alabama, together with a systematic catalogue of the plants growing in the state. Volume 5 of Monograph (Geological Survey of Alabama). Brown Printing Company, Montgomery, AL

Morgan, D.W., 2003. Mississippian Heritage: Late Woodland Subsistence and Settlement Patterns in the Mobile-Tensaw Delta, Alabama. Ph.D. Dissertation, Department of Anthropology, Tulane University, New Orleans, LA.

New South Associates, 1991. An Increase of the Town: An Archaeological and Historical Investigation of the Proposed Mobile Convention Center Site (1Mb194), Mobile, Alabama. New South Associates Technical Report 13. Stone Mountain GA.

United States Geological Survey National Wetlands Research Council (NWRC), 2007. 50 Years of Habitat Change in the Mobile Bay Delta. Lafayette, LA.

Osterman, L.E. and C.G. Smith, 2012. Over 100 years of environmental change recorded by foraminifers and sediments in Mobile Bay, Alabama, Gulf of Mexico, USA. Estuarine, Coastal and Shelf Science, 115:345-358.

Panamerican Consultants, 2001. Underwater Remote Sensing Survey, Dog River, Mobile County, Alabama. Prepared for U.S. Army Corps of Engineers, Mobile District.

Ritter, H.P., 1896. Report on a Reconnaissance of the Oyster Beds of Mobile Bay and Mississippi Sound, Alabama. Bulletin of the U.S. Fisheries Commission for 1895, pp 325-339.

Roach, E.R., M.C. Watzin, J.D. Scurry, and J. B. Johnston, 1987. Wetland changes in coastal Alabama. Pages 92-101 In: Lowery, T. A. (Ed.), Symposium on the Natural Resources of the Mobile Bay Estuary. February 1987, Mobile, AL. Alabama Sea Grant Extension Service Publication No. MASGP-87-007.

Romans, B., 1962. A Concise Natural History of East and West Florida. University of Florida Press, Gainesville. 342 pp.

Ryan, J.J., 1969. A sedimentologic study of Mobile Bay, Alabama. Florida State University, Dept. of Geology, Tallahassee, FL. Contribution No. 30. 110 pp.

Spencer, S. 1963. "Mobile Delta Survey". *In:* Summary Report on the Expanded Project for Aquatic Plant Control. Alabama Department of Conservation and Natural Resources. Contract Report to U.S. Army Corps of Engineers, Mobile District. 3 pp.

Stout, J.P. and M.G. Lelong, 1981. Wetland habitats of the Alabama coastal zone: Part II. An inventory of wetland habitats south of the Battleship Parkway. Technical Publication No. 81-01. Dauphin Island: Alabama Coastal Area Board. 47 pp.

Stout, J.P., M.J. Lelong, H.M. Dowling, and M.T. Powers, 1982. Wetland habitats of the Alabama Coastal Zone: Part III: An inventory of wetland habitats of the Mobile-Tensaw River Delta. Technical Report No. 81-49A. Dauphin Island: Alabama Coastal Area Board. 25 pp.

Summersell, C.G., 1957. Alabama History for Schools. Colonial Press, Birmingham, AL. 658

pp.

Thomason, Michael, 2001. Mobile: The New History of Alabama's First City. University of Alabama Press, Tuscaloosa. 416 pp.

Underwood, K.D. and F.D. Imsand, 1985. Hydrology, hydraulic, and sediment considerations of the Tennessee-Tombigbee Waterway. Environmental Geology and Water Sciences, 7:69-90.

U.S. Army Corps of Engineers (USACE), 1983. History of the Gulf Intracoastal Waterway. 85 pp.

U. S. Department of the Interior, 1970. Effects of Pollution on Water Quality of Perdido River and Bay, Alabama and Florida. Federal Water Pollution Control Administration, Southeast. Athens, GA. 33 pp.

Walthall, J.A., 1980. Prehistoric Indians of the Southeast: Archaeology of Alabama and the Middle South. University of Alabama Press, Tuscaloosa. 320 pp.

Zolcyznski, J. and R.H. Shearer, 1997. Mobile Delta submersed aquatic vegetation survey: 1994. Alabama Department of Conservation and Natural Resources. Final Report. 28 pp.

Attachment 3 – Maps of Physical and Biological Features

List of Figures

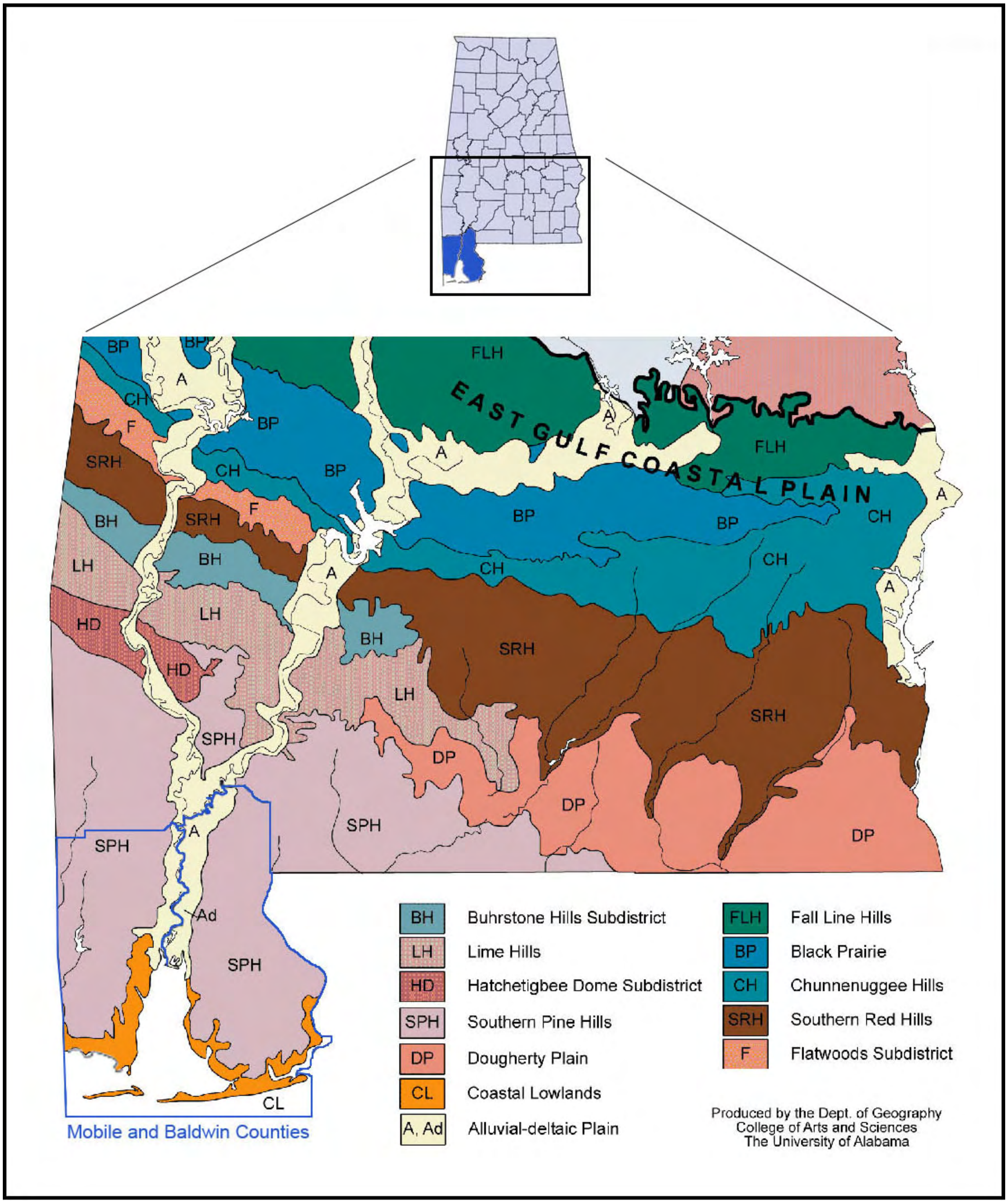


Figure 1. Physiographic subdivisions of southern Alabama.

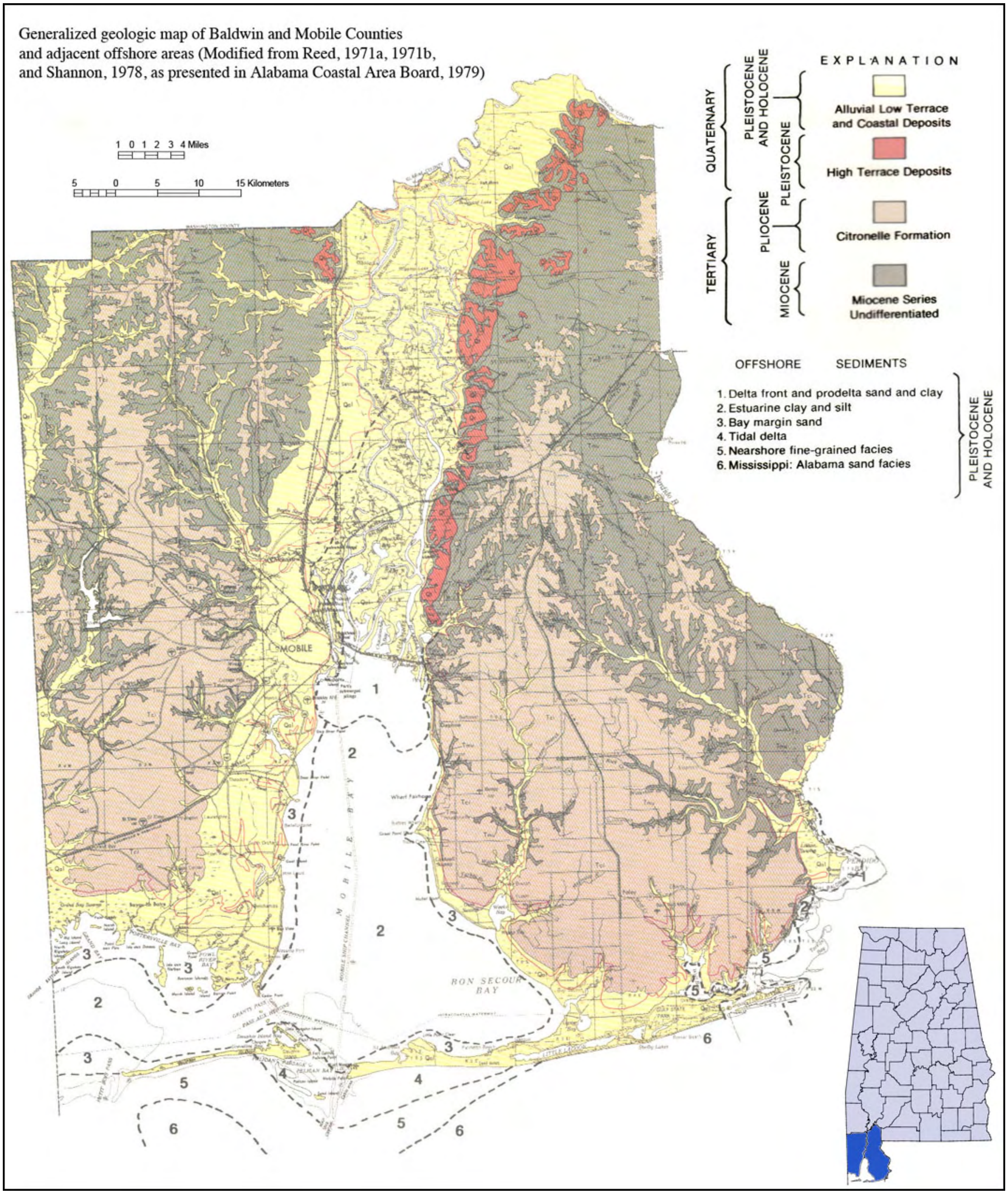


Figure 2. Generalized geologic map of Mobile and Baldwin Counties (Alabama Coastal Area Board, 1979).

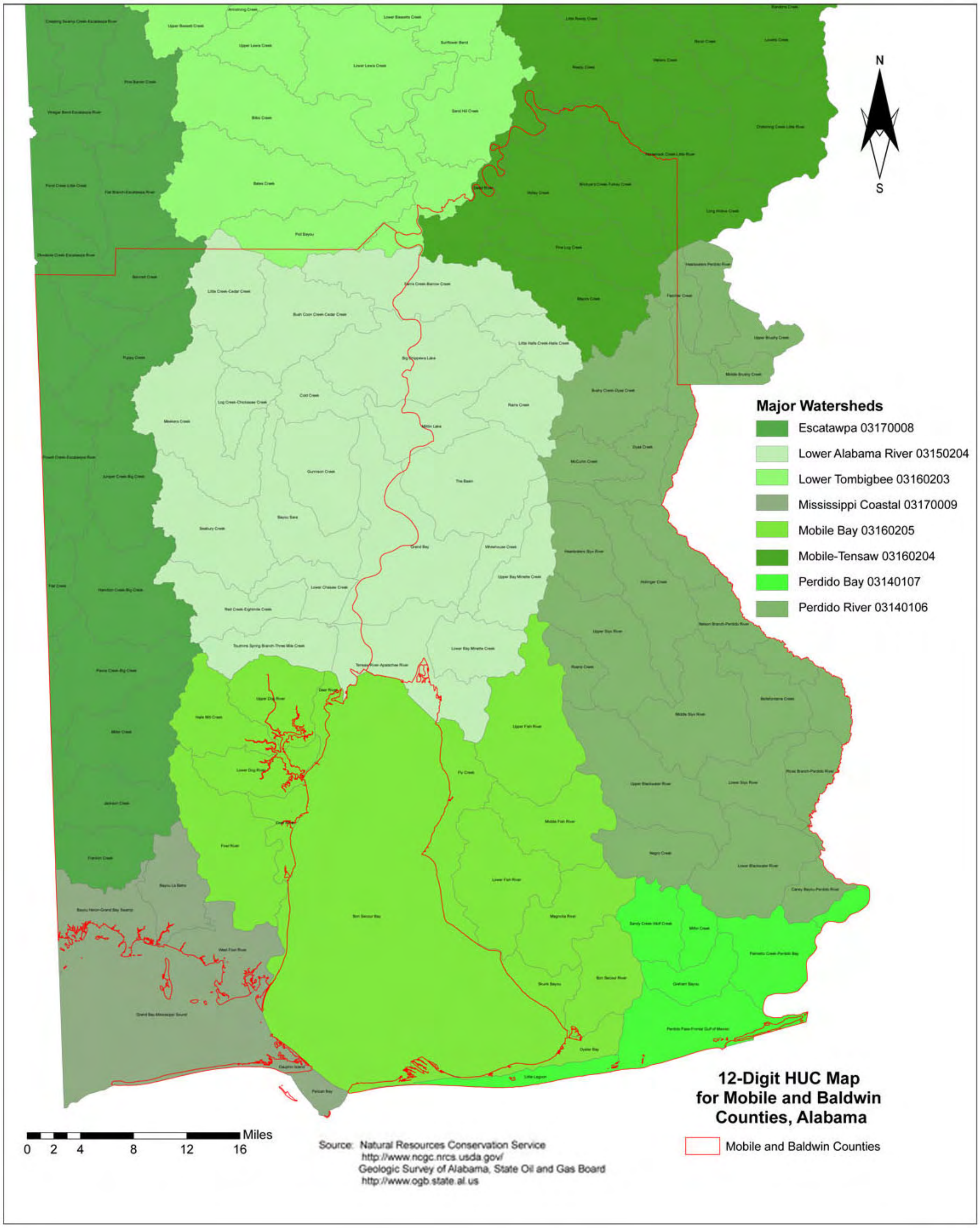


Figure 3. Watersheds of Mobile and Baldwin Counties.

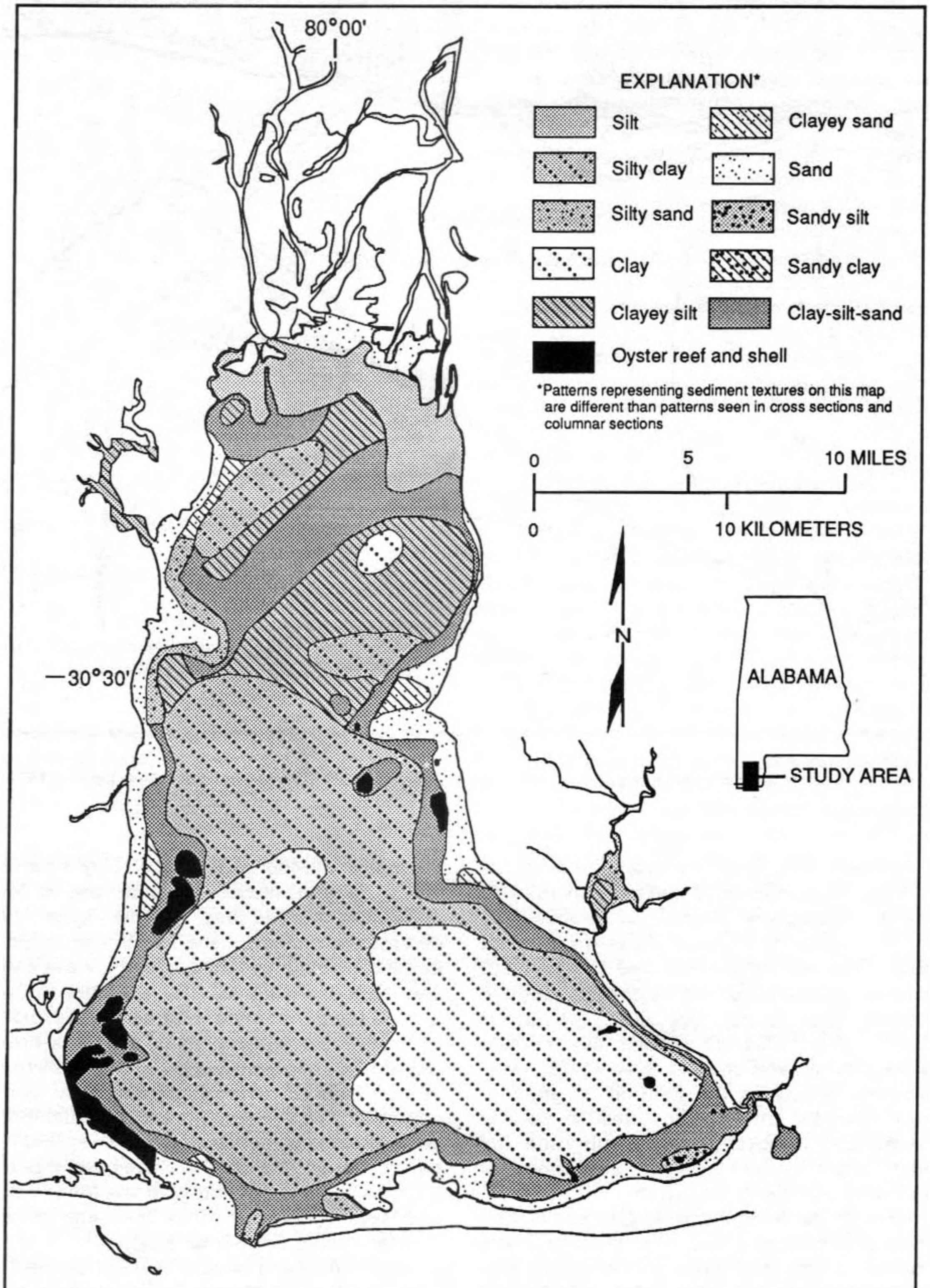


Figure 6.--Mobile Bay bottom sediment map, 1969 (modified from Ryan, 1969).

Figure 4. Mobile Bay bottom sediment map (Ryan, 1969; modified from Hummell and Parker, 1995a).

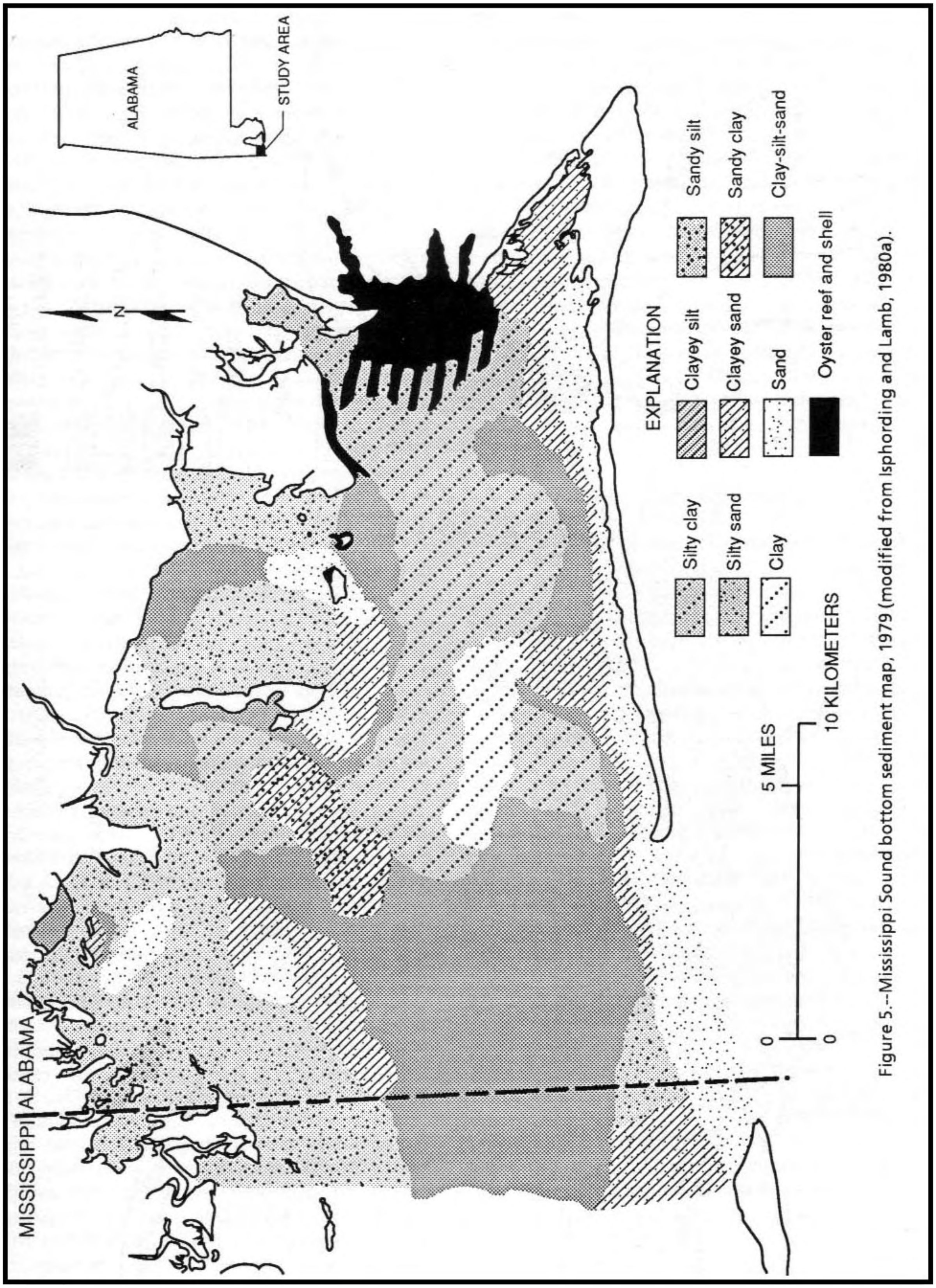


Figure 5. Mississippi Sound bottom sediment map (modified from Ishphording and Lamb, 1980, as presented in Hummell and Parker, 1995b).

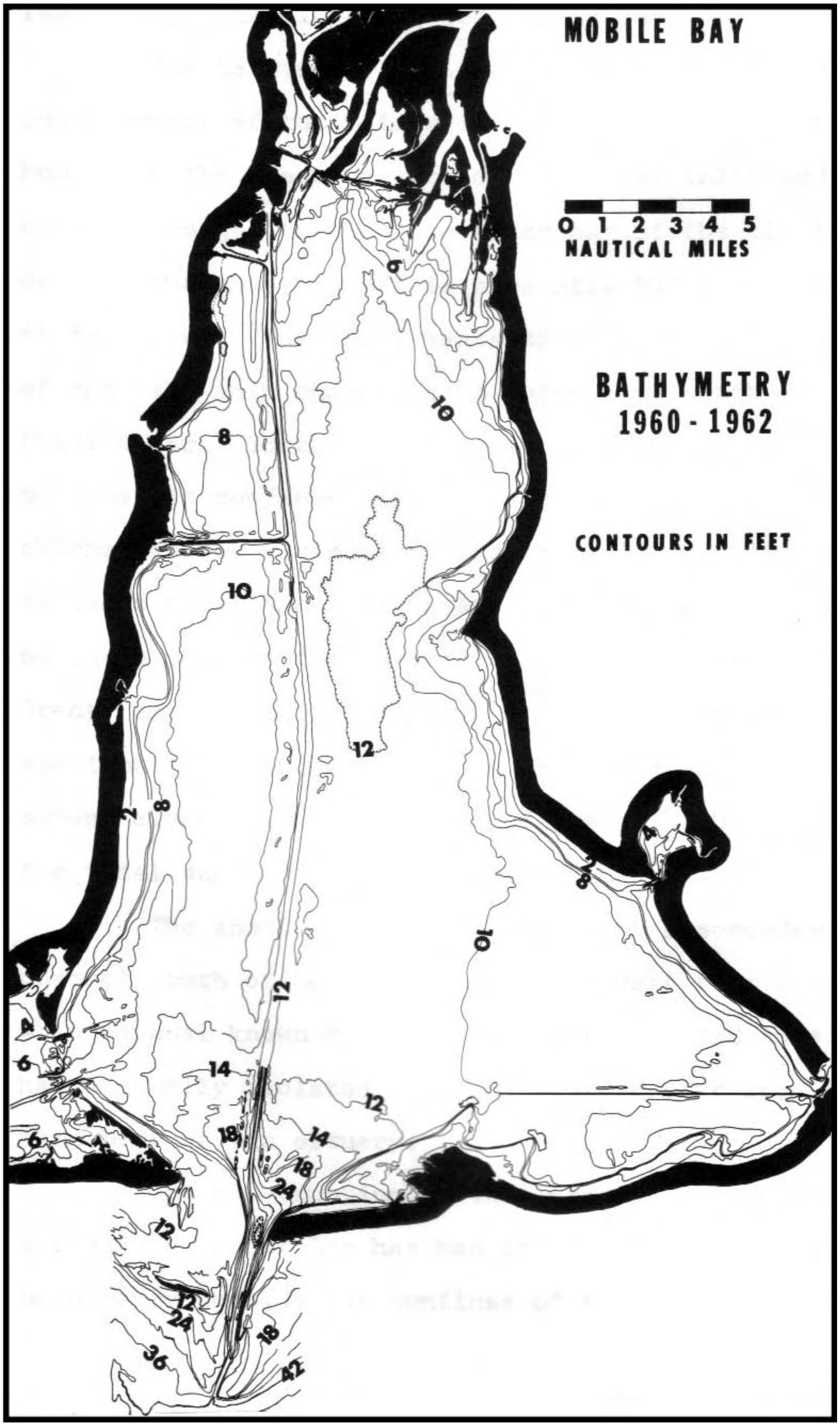


Figure 6. Mobile Bay bathymetry (Ryan, 1969).

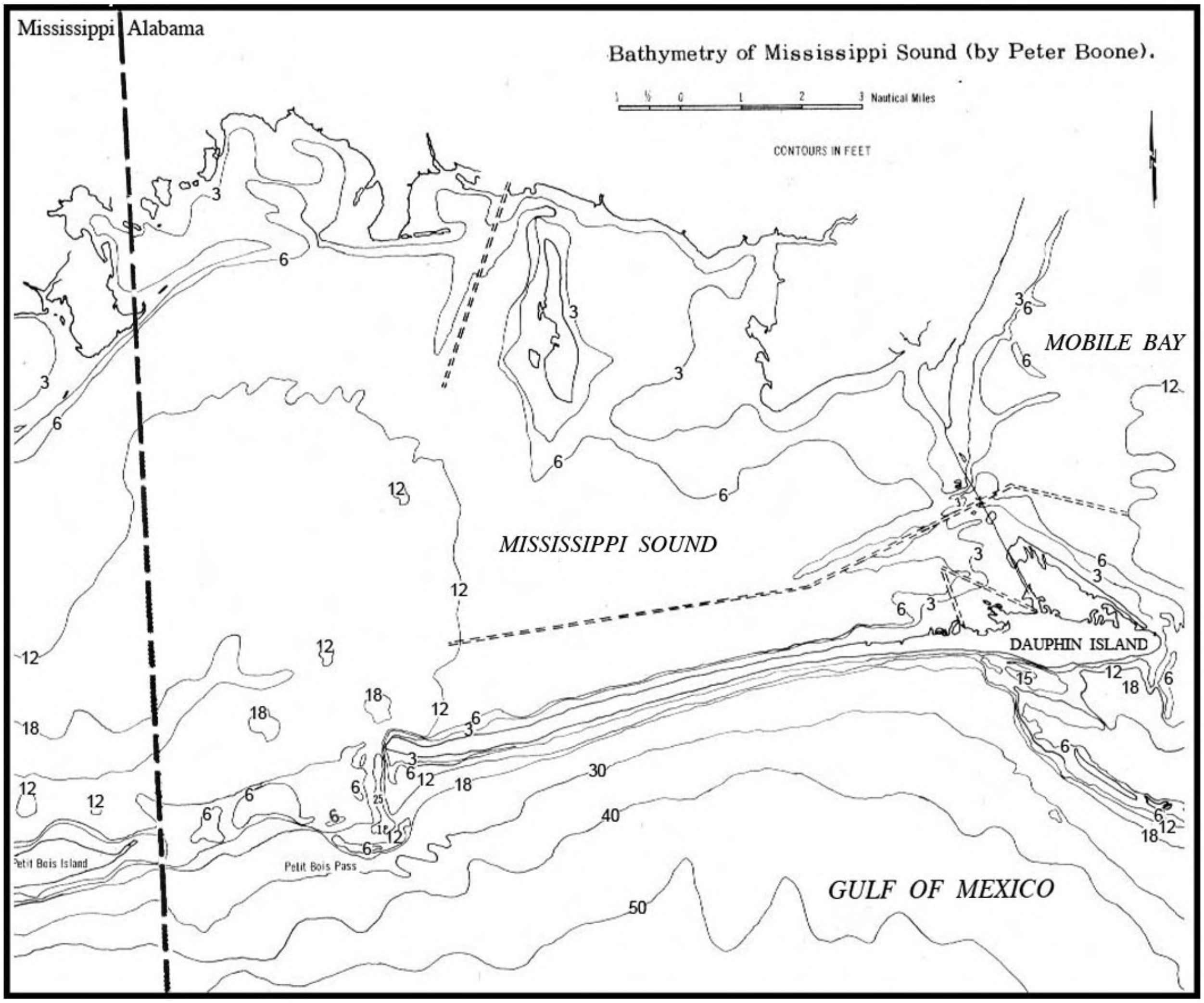


Figure 7. Mississippi Sound bathymetry (modified from Boone, 1972).

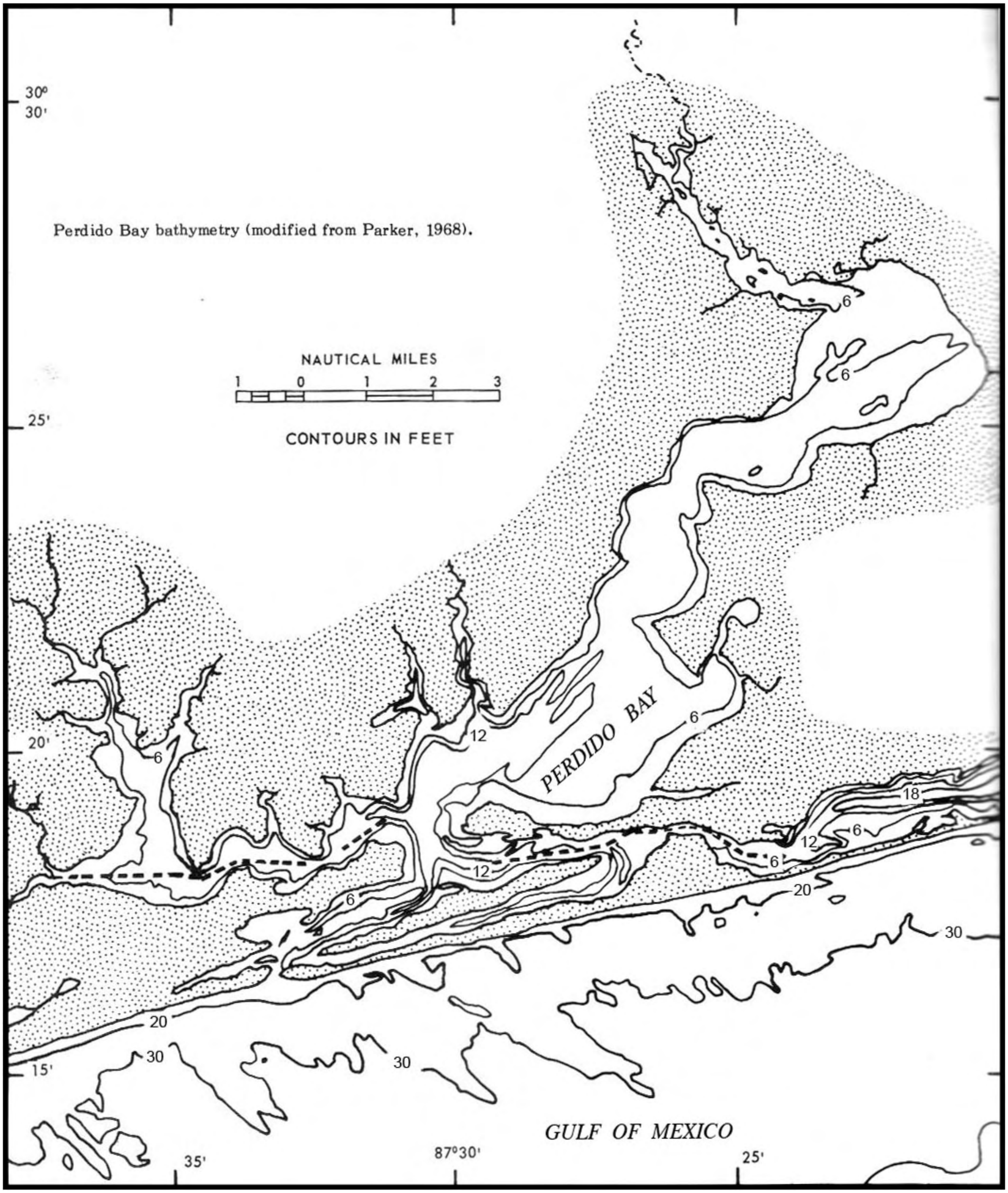


Figure 8. Perdido Bay bathymetry (modified from Parker, 1968).

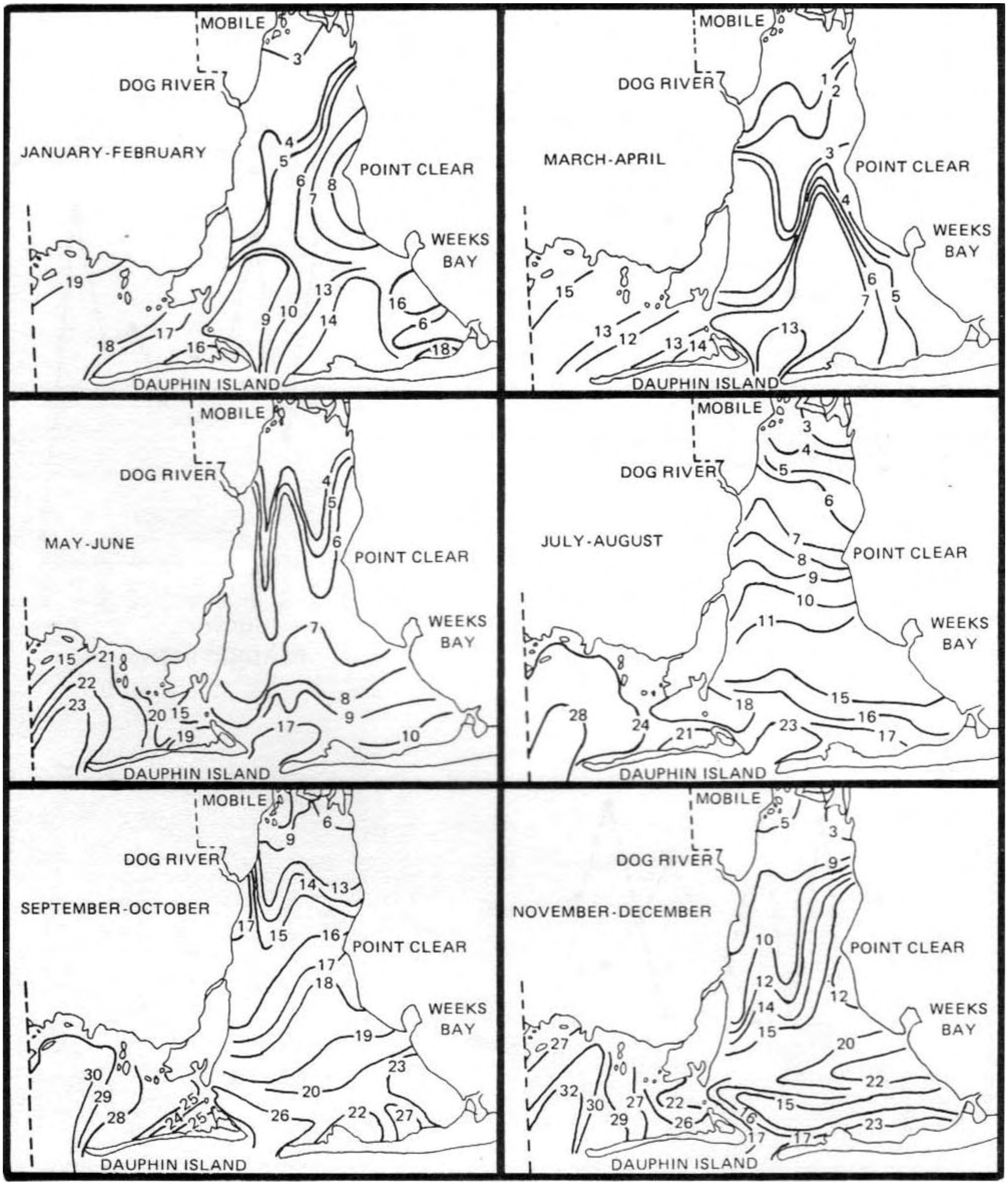


Figure 9. Bimonthly surface isohaline maps of Mobile Bay and Mississippi Sound (Bault, 1972).

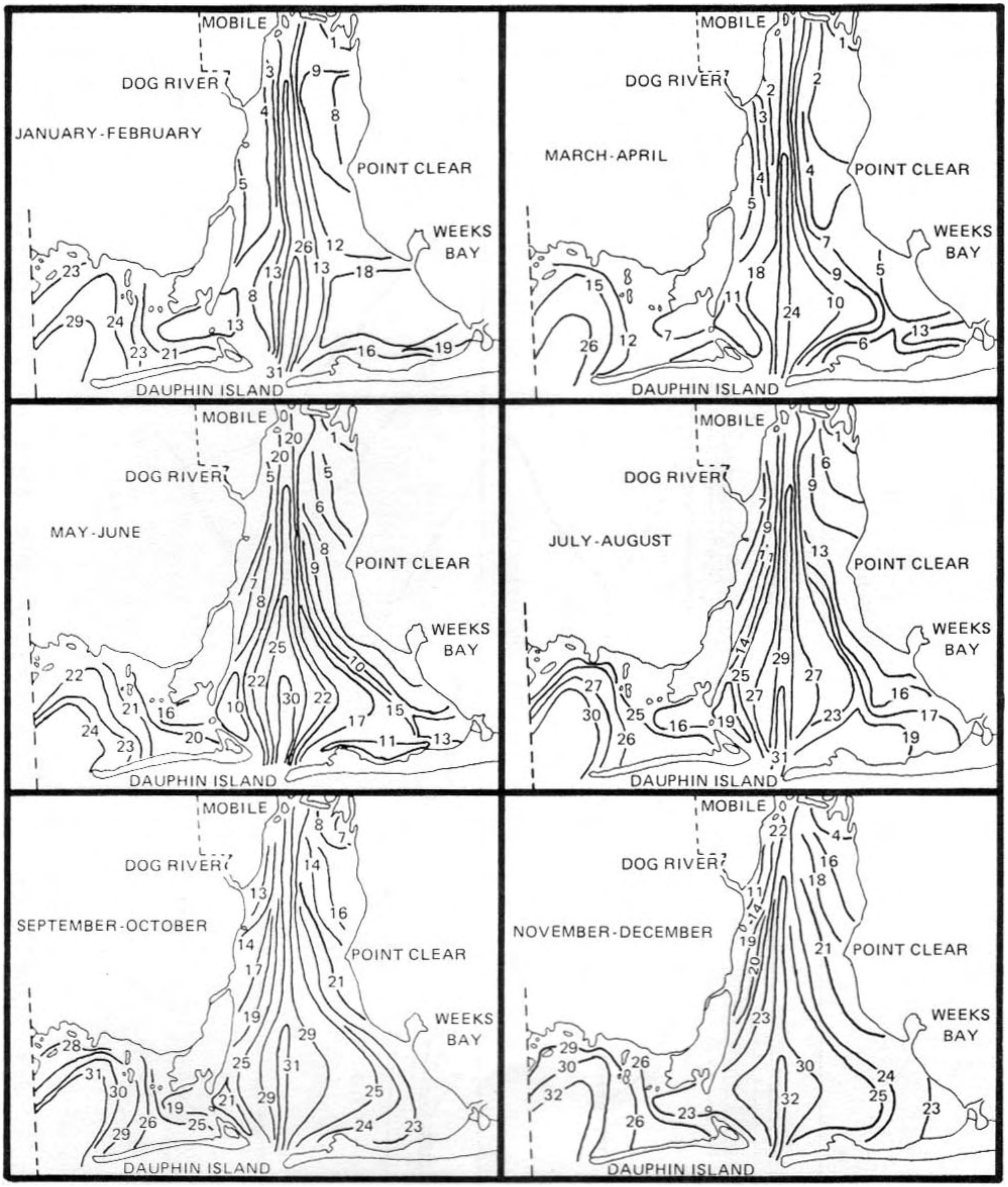


Figure 10. Bimonthly bottom isohaline maps of Mobile Bay and Mississippi Sound (Bault, 1972).

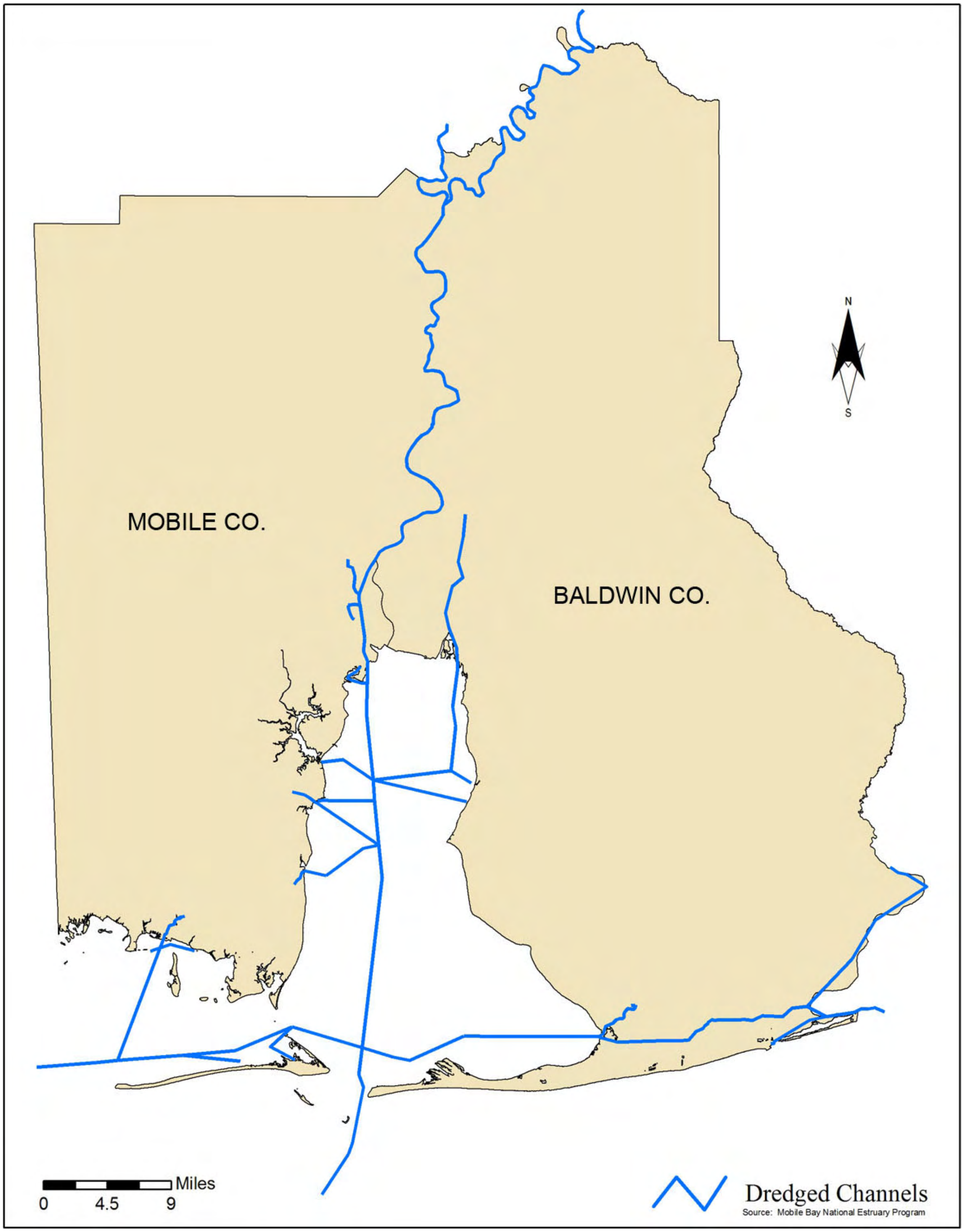


Figure 11. Dredged channels in coastal Alabama.

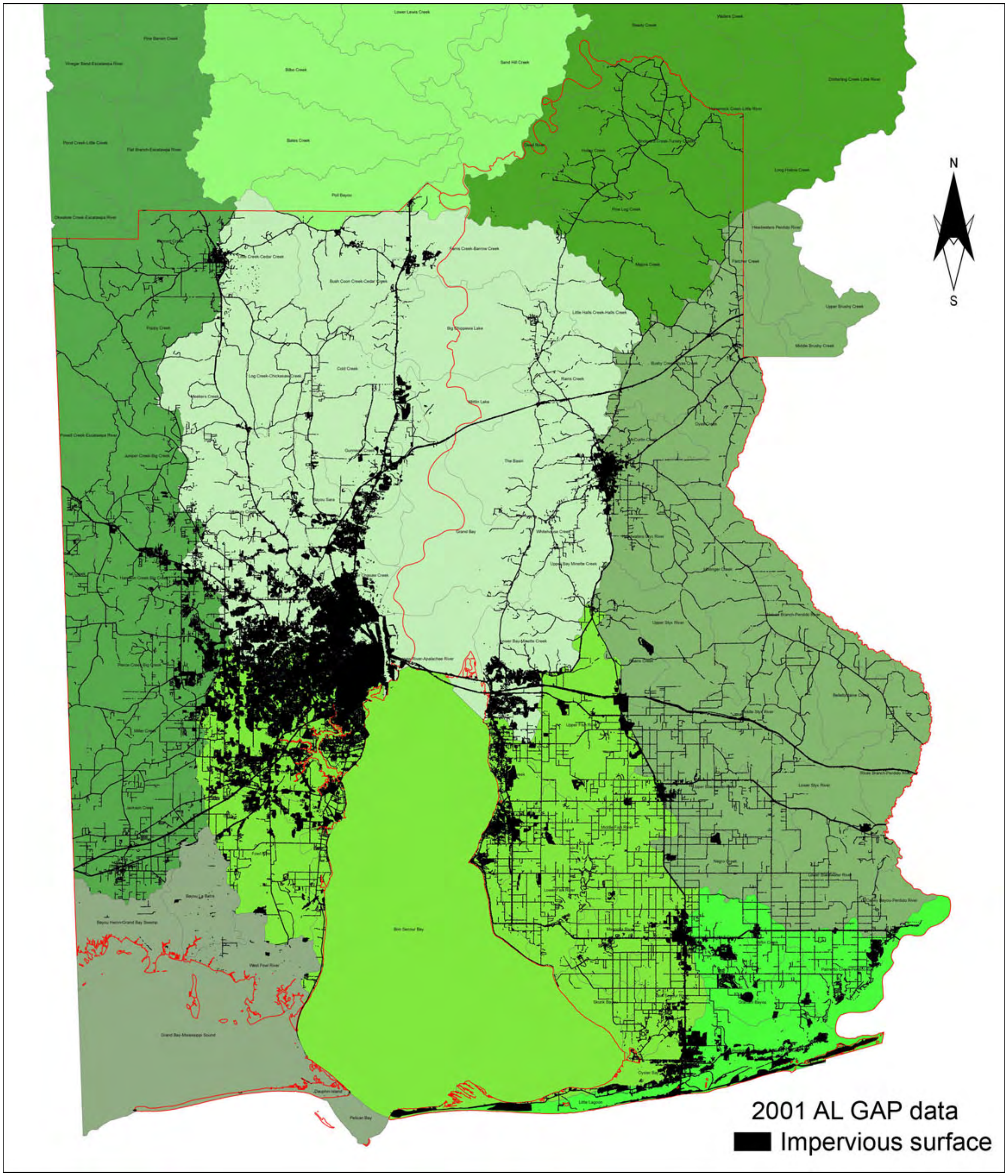


Figure 12. Impervious surfaces in Mobile and Baldwin Counties.

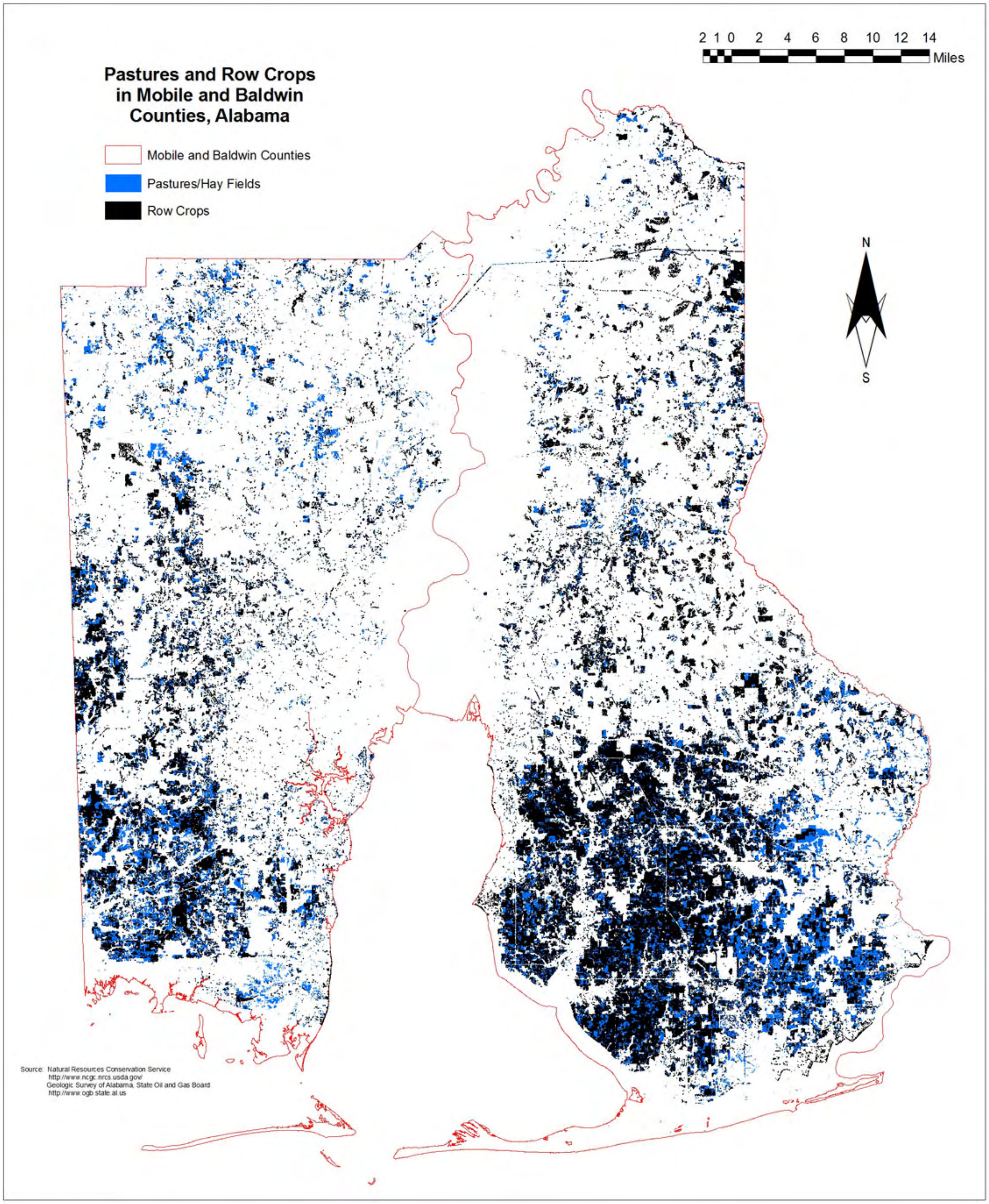


Figure 13. Row crop and pasture lands in Mobile and Baldwin Counties.

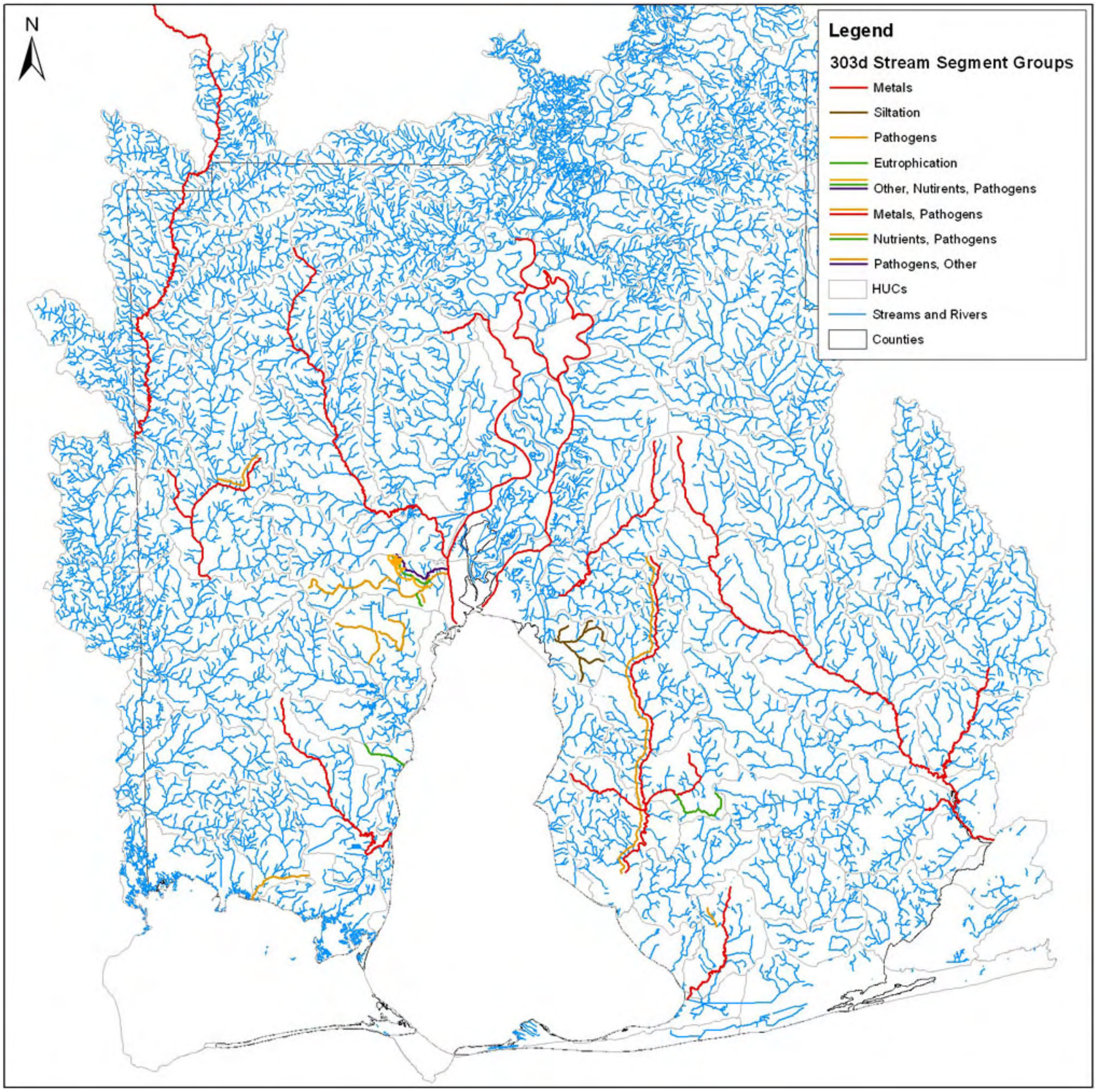


Figure 14. Section 303(d) impaired streams in Mobile and Baldwin Counties.

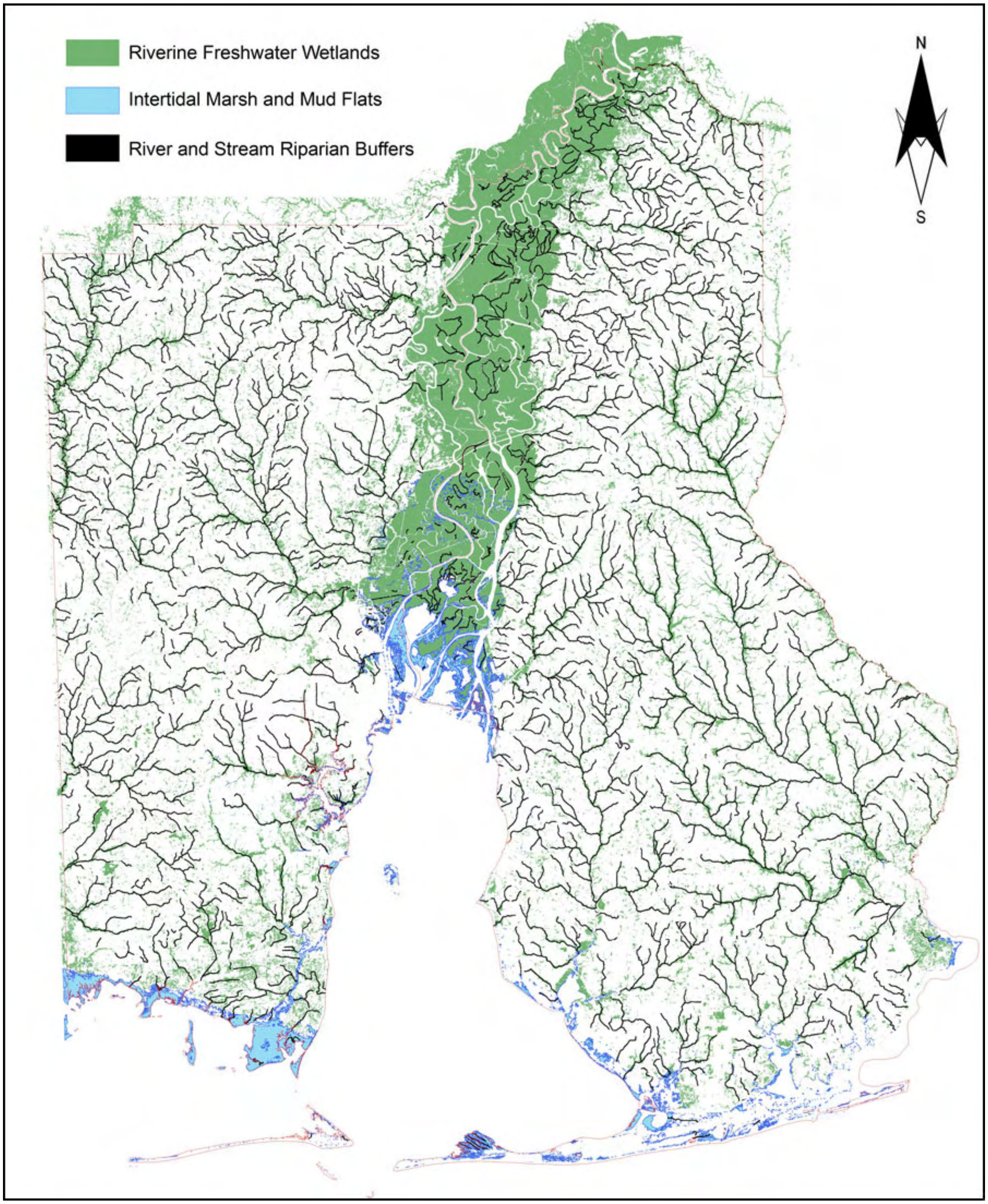
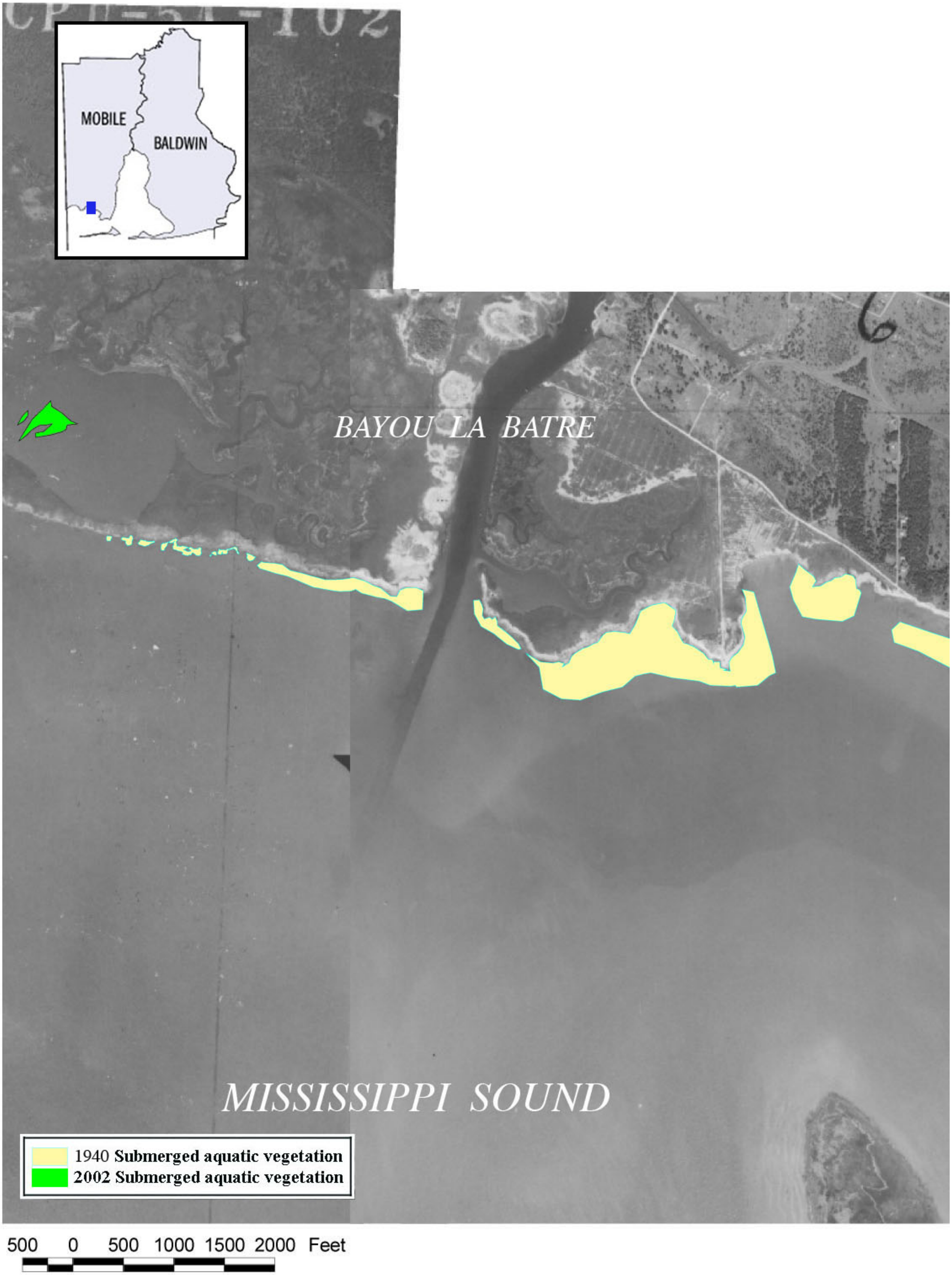
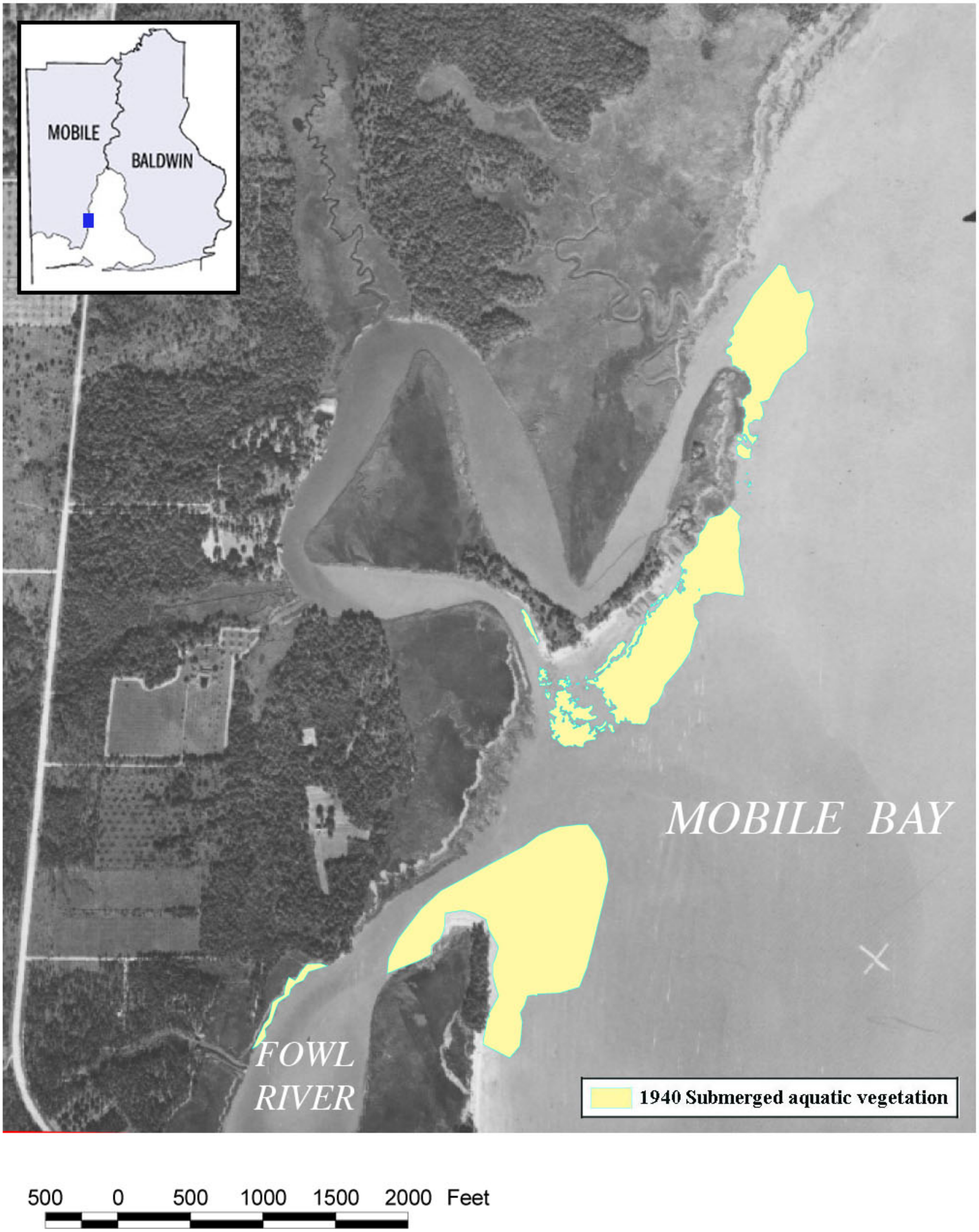


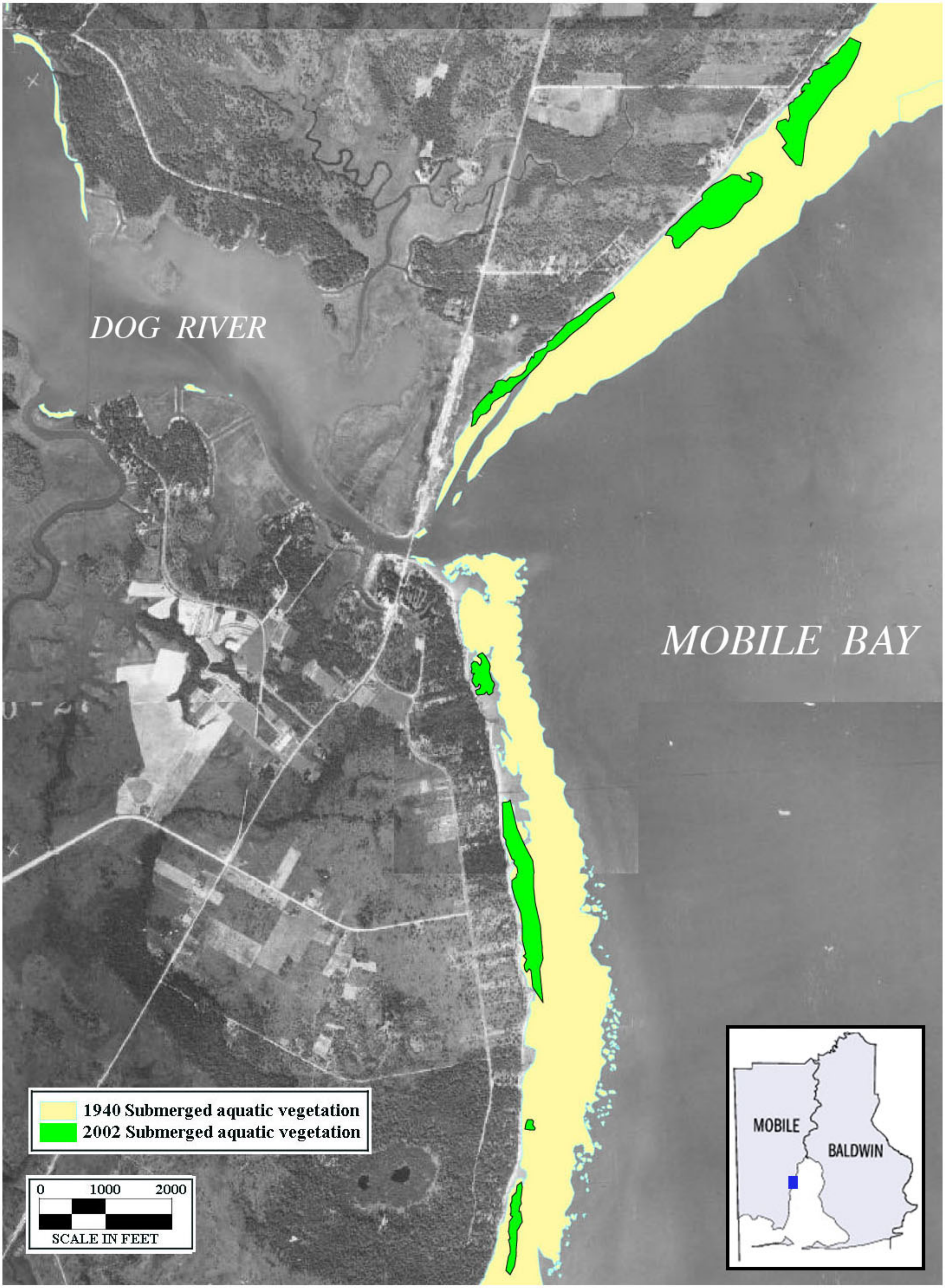
Figure 15. Freshwater wetlands, intertidal marshes and flats, streams and rivers, and riparian areas in Mobile and Baldwin Counties (Source: ALGAP, 2001).

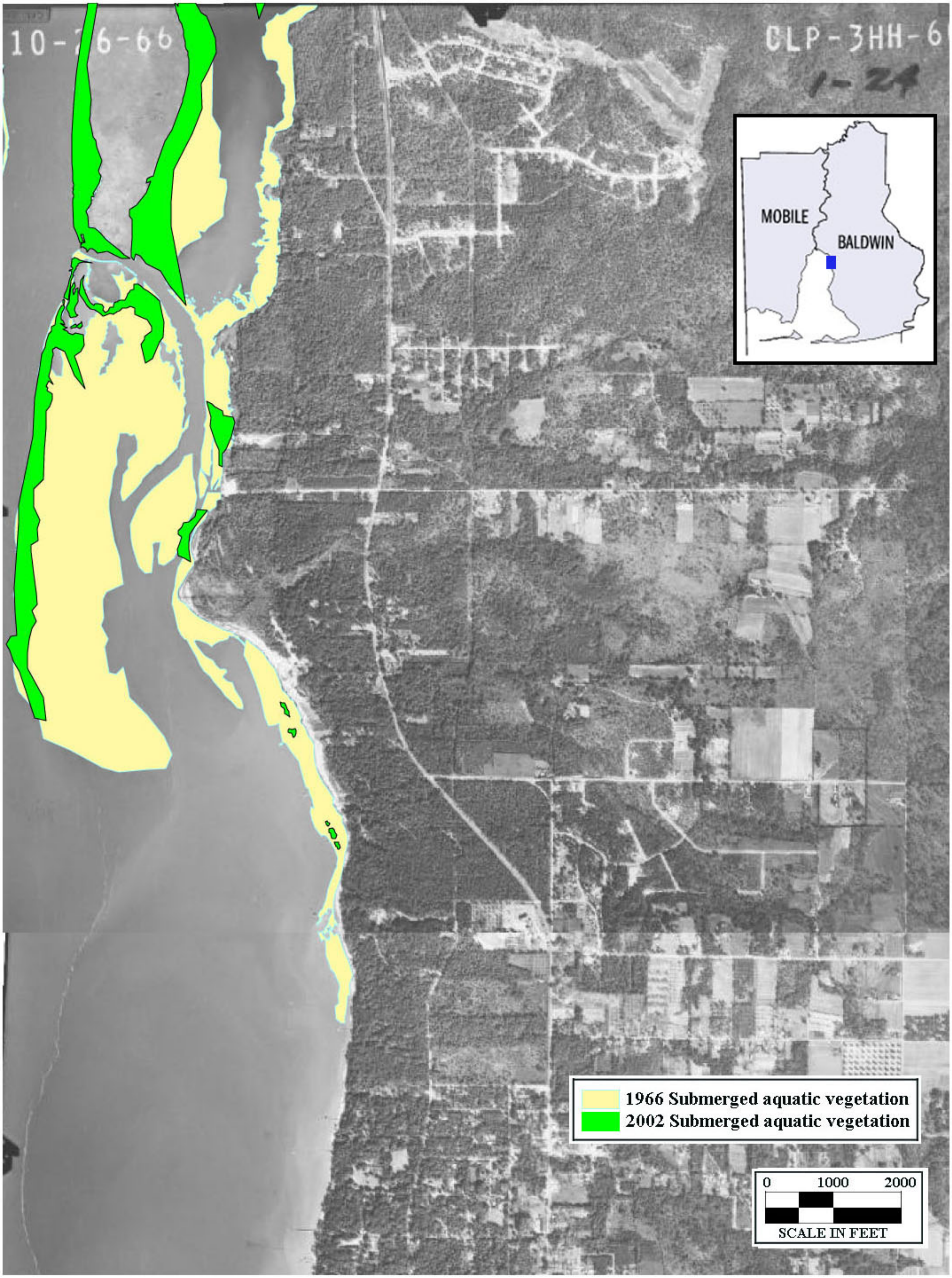
Attachment 4 – Maps of Historic and Recent SAV and Oyster Reef Distributions

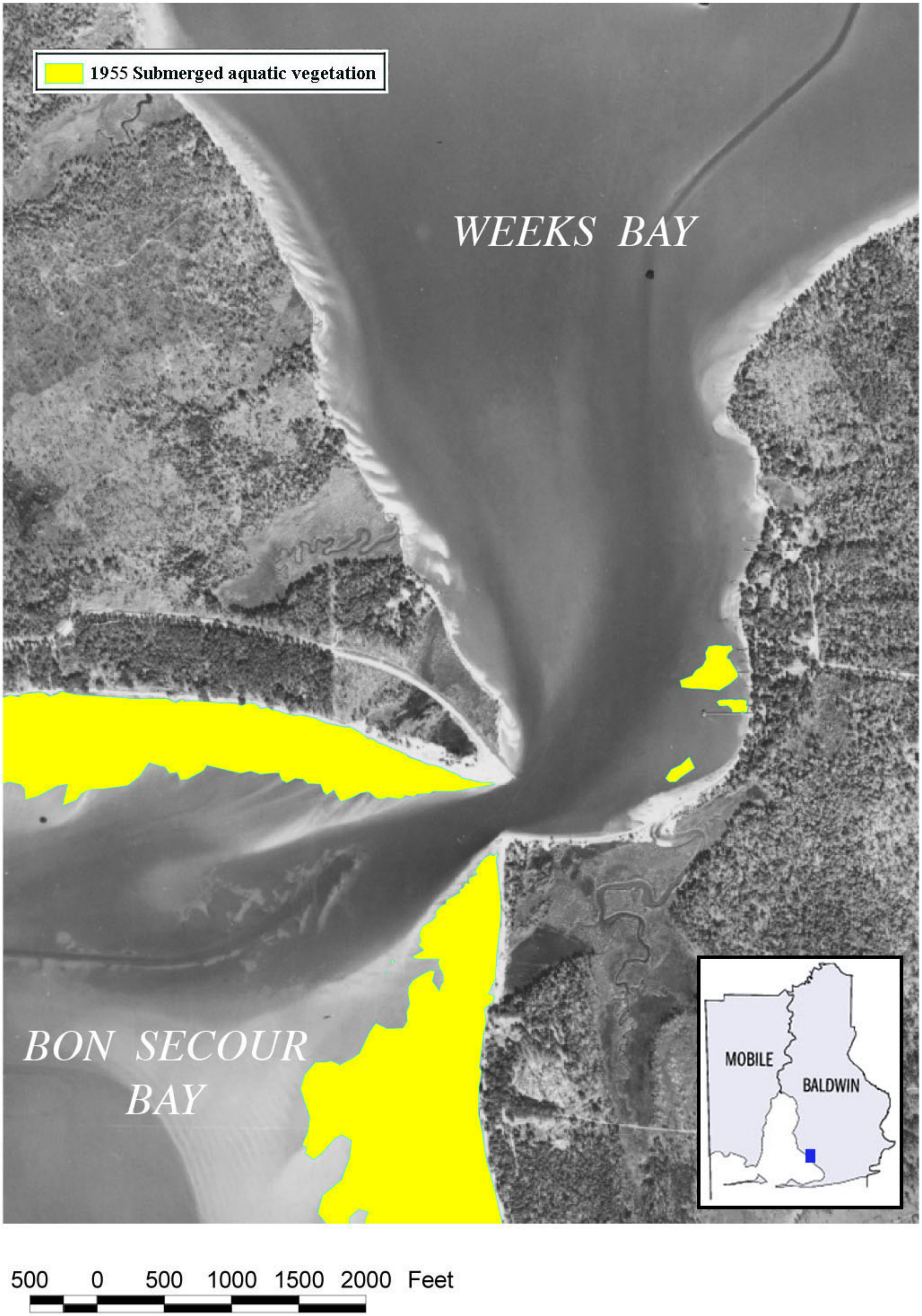

CPE-5A-102
MOBILE
BALDWIN
BAYOU LA BATRE
MISSISSIPPI SOUND
1940 Submerged aquatic vegetation
2002 Submerged aquatic vegetation
500 0 500 1000 1500 2000 Feet

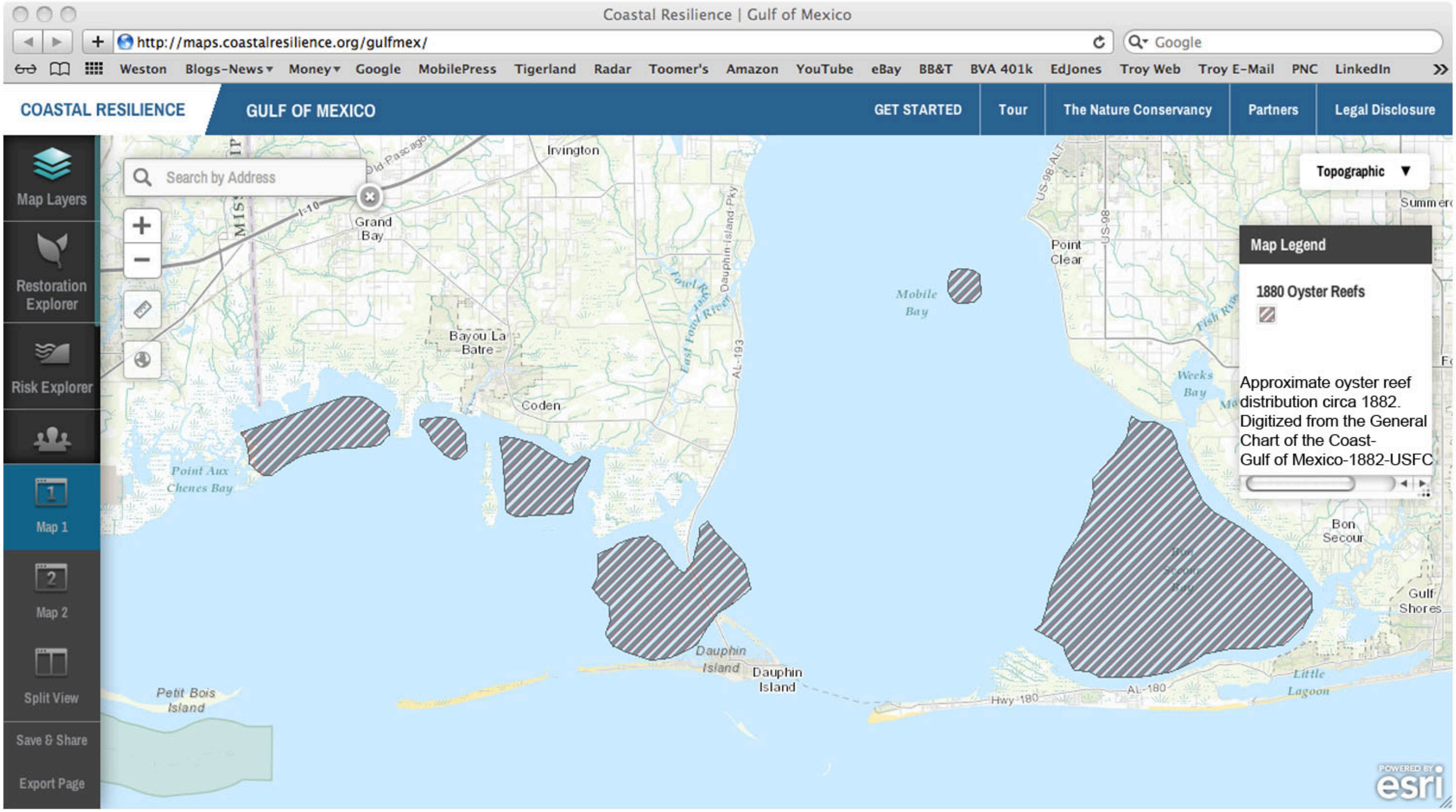


MOBILE
BALDWIN
MOBILE BAY
FOWL RIVER
1940 Submerged aquatic vegetation
500 0 500 1000 1500 2000 Feet


DOG RIVER
MOBILE BAY
1940 Submerged aquatic vegetation
2002 Submerged aquatic vegetation
0
1000
2000
SCALE IN FEET
MOBILE
BALDWIN


10-26-66
CLP-3HH-6
1-24
MOBILE
BALDWIN
1966 Submerged aquatic vegetation
2002 Submerged aquatic vegetation
0
1000
2000
SCALE IN FEET


1955 Submerged aquatic vegetation
WEEKS BAY
BON SECOUR
BAY
MOBILE
BALDWIN
500 0 500 1000 1500 2000 Feet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Restoration Explorer
Risk Explorer
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Map 2
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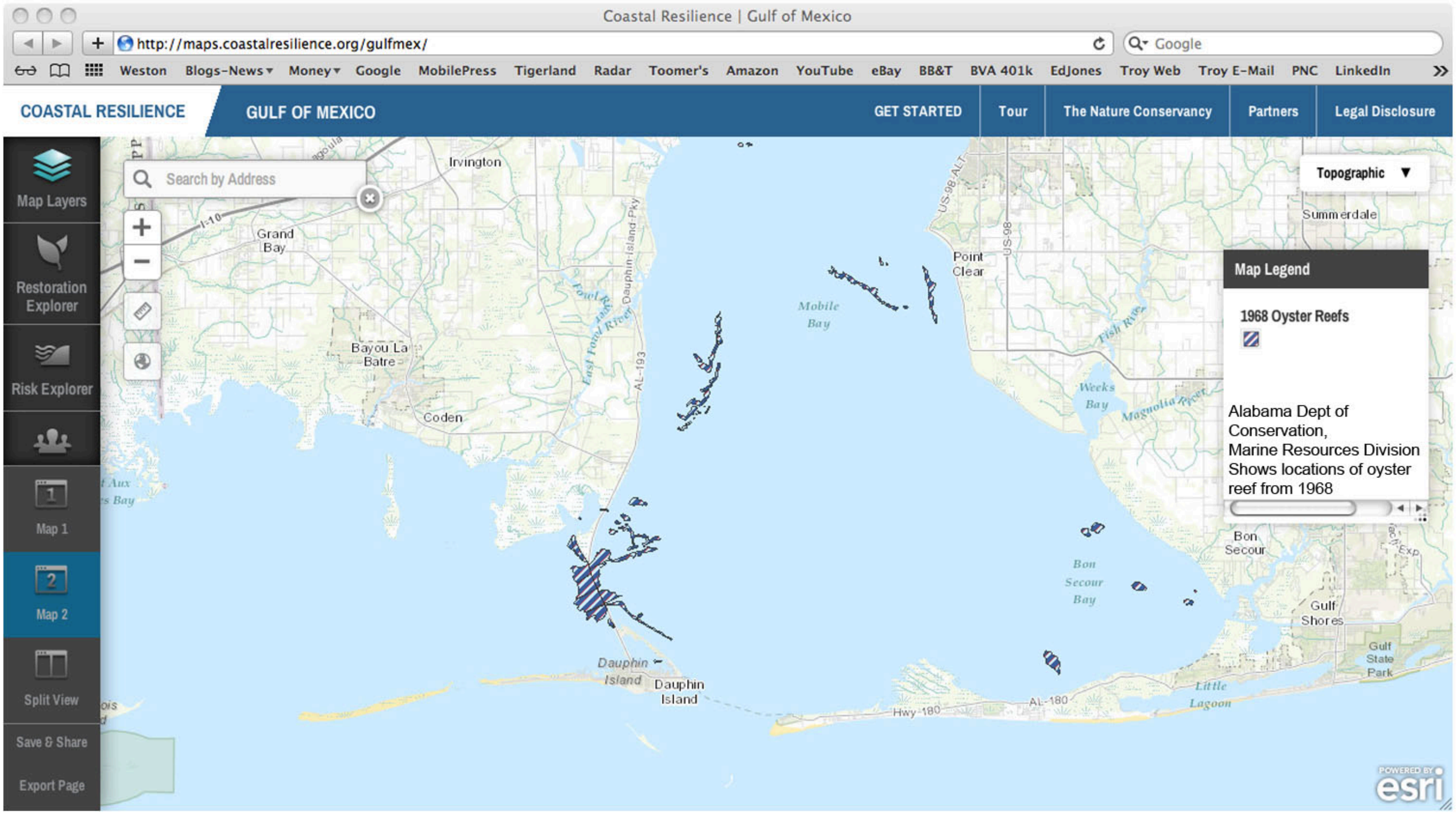
Topographic
Map Legend
1880 Oyster Reefs
Approximate oyster reef distribution circa 1882. Digitized from the General Chart of the Coast- Gulf of Mexico-1882-USFC
Irvington
Grand Bay
Bayou La Batre
Coden
Point Aux Chenes Bay
Petit Bois Island
Dauphin Island
Mobile Bay
Point Clear
Weeks Bay
Bon Secour
Gulf Shores
Little Lagoon
AL-193
AL-180
Hwy-180
US-98
I-10
esri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Amazon
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eBay
BB&T
BVA 401k
EdJones
Troy Web
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PNC
LinkedIn
COASTAL RESILIENCE
GULF OF MEXICO
GET STARTED
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The Nature Conservancy
Partners
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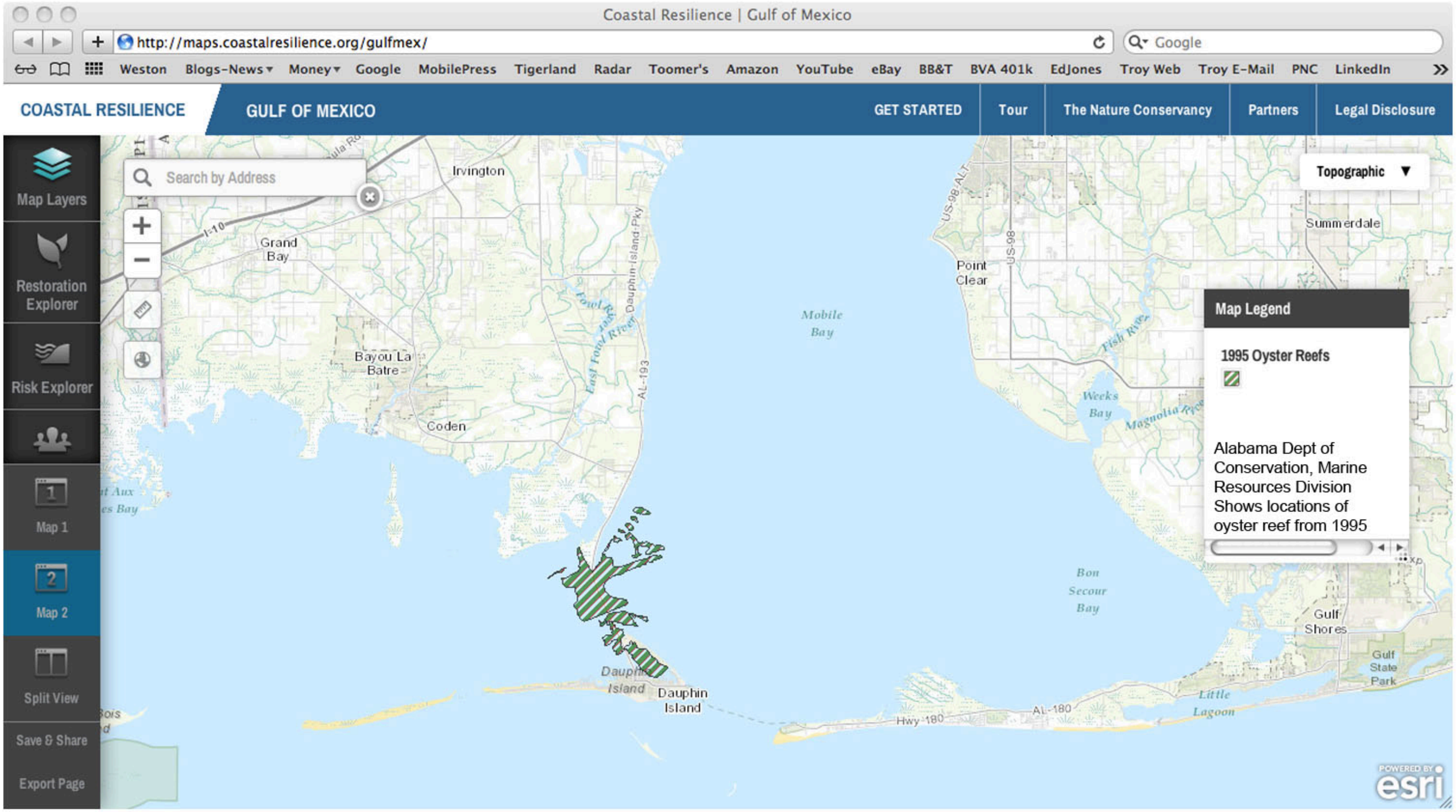
Map Layers
Restoration Explorer
Risk Explorer
Map 1
Map 2
Split View
Save & Share
Export Page
Search by Address
Topographic
Irvington
Grand Bay
Bayou La Batre
Coden
Mobile Bay
Point Clear
Weeks Bay
Bon Secour
Bon Secour Bay
Gulf Shores
Gulf State Park
Little Lagoon
Dauphin Island
Dauphin Island
Hwy-180
AL-180
AL-193
Summerdale
Map Legend
1968 Oyster Reefs
Alabama Dept of Conservation,
Marine Resources Division
Shows locations of oyster reef from 1968
POWERED BY esri



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http://maps.coastalresilience.org/gulfmex/
COASTAL RESILIENCE
GULF OF MEXICO
GET STARTED
Tour
The Nature Conservancy
Partners
Legal Disclosure
Map Layers
Restoration Explorer
Risk Explorer
Map 1
Map 2
Split View
Save & Share
Export Page
Search by Address
Topographic
Map Legend
1995 Oyster Reefs
Alabama Dept of Conservation, Marine Resources Division
Shows locations of oyster reef from 1995
Irvington
Grand Bay
Bayou La Batre
Coden
Mobile Bay
Point Clear
Summerdale
Weeks Bay
Bon Secour Bay
Gulf Shores
Gulf State Park
Little Lagoon
Dauphin Island