
AN ANNOTATED BIBLIOGRAPHY OF LITERATURE ON ESTUARINE & MARINE RESOURCES RELATIVE TO THE PORT OF GULFPORT RESTORATION PROGRAM, MISSISSIPPI

Prepared by:

Volkert and Associates, Inc.
162 Porter Avenue
Biloxi, MS 39530
&
Gulf Coast Research Laboratory
University of Southern Mississippi
703 E. Beach Drive
Ocean Springs, MS 39564

For:

CH2M Hill
1701-B 24th Avenue
Gulfport, MS 39501
&
Mississippi State Port Authority
2510 14th Street, Suite 1450
Gulfport, MS 39501

March 2010

Table of Contents

BACKGROUND & INTRODUCTION	1
3.1 Fisheries Species.....	2
3.2 Threatened, Endangered, or Protected Species	68
3.2.1 Marine Mammals	68
3.2.2 Sea Turtles	74
3.2.3 Fish.....	76
3.3 Environmental Impact Statements	78
3.4 Seagrasses.....	87
3.4.1 General Threats to Seagrasses	87
3.4.2 Seagrass Annotated Bibliography.....	96
3.5 Benthic Community.....	102

BACKGROUND & INTRODUCTION

On August 29, 2005, Hurricane Katrina made landfall near the Port of Gulfport (Port) in Gulfport, Mississippi, causing extensive infrastructure damage. Rebuilding and revitalization of the Port as part of the Port of Gulfport Restoration Program (PGRP) will require environmental studies to document existing conditions within and around the area of the Port for permitting purposes. This document summarizes existing publications, reports and data for marine and estuarine resources (wetlands, submerged aquatic vegetation, essential fish habitat (EFH), and estuarine/marine species, including threatened and endangered species) relative to the PGRP. A bibliographic summary of Gulf sturgeon (*Acipenser oxyrinchus desotoi*) and its critical habitat relative to the PGRP has been compiled in a separate document. The environmental study area considered for this bibliography is the Port, the surrounding waters of the Port, and the Gulfport navigation channel.

The format of this document has been expanded beyond standard annotated bibliographic formats in order to provide sufficient information to determine the relevance of cited data to PGRP-related studies and permitting requirements (e.g., information on sample collection period is included to aid in determining if study data fall within acceptable time limits for permitting purposes). Additionally, because identical data may be contained in both technical reports and subsequent peer-review publications, the format provides for a "Related Documents" summary; in such instances, the peer-review publication is listed and summarized in the bibliography with associated technical reports and/or data summaries listed as Related Documents to reduce duplication and aid in the review process.

3.4 Seagrasses

3.4.1 General Threats to Seagrasses

Badalamenti, F., G. Di Carlo, G. D' Anna, M. Gristina and M. Toccaceli. 2006. Effects of dredging activities on population dynamics of *Posidonia oceanica* (L.) Delile in the Mediterranean Sea: the case study of Capo Feto (SW Sicily, Italy). *Hydrobiologia* 555: 253-261.

Sampling or Data Summary Period: 1981-1998

Publication Type: Peer-review journal

Abstract: Between 1981 and 1993 a methane pipeline was deployed between Sicily (Italy) and Tunisia. This involved the construction of a pipeline trench, which damaged the *Posidonia oceanica* (L.) Delile meadow at Capo Feto (SW Sicily, Italy) and disturbed the surrounding meadow. Seagrass growth and population dynamics were examined at different depth ranges and at increasing distances from the construction site outer limit (5, 15, 30, 50 m). Results showed significant differences between the shallow (10 ± 3.3 m) and the deep (20 ± 4.6 m) meadow as well as differences among distances. The age structure of *P. oceanica* varied along the distance gradient and with depth. The mortality rate decreased with distance from the trench at all depth ranges, showing that the plants close to the excavation suffered a higher level of disturbance. Turnover and annual gross shoot recruitment rate (R_{gross}) were higher in the shallow portion of the meadow than in the deep range. Forecast of future meadow development (R_{net}) close to the trench indicates that, if present conditions are maintained, shoot density will be reduced by 50% over the next 6 to 17 years.

Comments: Not applicable

Boudouresque, C.F., G. Bernard, G. Pergent, A. Shili, and M. Verlaque. 2009. Regression of Mediterranean seagrasses caused by natural processes and anthropogenic disturbances and stress: a critical review. *Botanica Marina* 52: 395-418.

Sampling or Data Summary Period: Literature review (1970-2009)

Publication Type: Peer-review journal

Abstract: Seagrass meadows are considered to be among the most important marine ecosystems, with regard to both ecology and biodiversity and for the services they provide. Seven species occur in the Mediterranean Sea: *Posidonia oceanica* (the most common in the open sea), *Cymodocea nodosa* (particularly common in the eastern basin), *Ruppia cirrhosa*, *R. maritima*, *Zostera marina* and *Zostera noltii* (mainly in estuaries and brackish lagoons), and *Halophila stipulacea* (introduced from the Red Sea). Seagrass regression may be due to natural processes and/or natural or anthropogenic disturbances and stress. It can also be due to long-term climate trends, e.g. the post-Last Glacial Maximum rise in sea-level, the Little Ice Age (LIA) cooling and the post-LIA warming, resulting in possible misinterpretation. Human-induced losses of *P. oceanica* have been mainly related to coastal development, pollution, trawling, fish farming, moorings, dredging, dumping and introduced species. All other seagrasses have also undergone more or less dramatic regression events. In fact, accurate data are generally of very local value and they are lacking for most of the Mediterranean Sea. In the absence of a reliable baseline, some widely cited cases of regression are questionable. Relatively healthy *P. oceanica* meadows, whose limits have changed little since the 1950's, may thrive in highly anthropized areas. In addition, the decline of one species can benefit another, so that the overall seagrass balance may remain unchanged (e.g., *Cymodocea* replacing *Posidonia*). However, to

conclude that everything is for the best would be erroneous. First, the lack of data supporting the general regression hypothesis does not invalidate the hypothesis. Indisputably dramatic seagrass losses have been documented (e.g., *P. oceanica* and *Z. marina*). Second, the *Posidonia* regression is irreversible at human scales, while other seagrasses can rapidly recover, and the expansion of some seagrasses (e.g., *Cymodocea*) cannot counterbalance, in terms of ecosystem services, the decline of the *P. oceanica* meadows. Third, human pressure (demography, tourism, etc.) on Mediterranean seagrass ecosystems is destined to strongly increase in the coming decades. Finally, the rise in sea-level due to global climate change will automatically induce a withdrawal of the lower limit of seagrass meadows whenever the limit is beyond the compensation depth. So the regression trend observed in Mediterranean seagrasses, even if it proves to be currently weaker than postulated, will significantly increase and become a major concern in the future. There is therefore an urgent need for the adoption of a set of efficient indicators and the setting up of a robust comparative baseline in order to draw up an accurate assessment of the losses and, for seagrasses other than *Posidonia*, possible gains at Mediterranean scale. In addition, seagrasses and seagrass habitats should be granted legal protection and, where such protection already exists, it should be implemented.

Comments: Not applicable

Erftemeijer, P.L.A. and R.R.R. Lewis III. 2006. Environmental impacts of dredging on seagrasses: A review. *Marine Pollution Bulletin* 52: 1553-1572.

Sampling or Data Summary Period: Literature review (1940-2005)

Publication Type: Peer-review journal

Abstract: Main potential impacts on seagrasses from dredging and sand mining include physical removal and/ or burial of vegetation and effects of increased turbidity and sedimentation. For seagrasses, the critical threshold for turbidity and sedimentation, as well as the duration that seagrasses can survive periods of high turbidity or excessive sedimentation vary greatly among species. Larger, slow-growing climax species with substantial carbohydrate reserves show greater resilience to such events than smaller opportunistic species, but the latter display much faster post - dredging recovery when water quality conditions return to their original state. A review of 45 case studies worldwide, accounting for a total loss of 21,023 ha of seagrass vegetation due to dredging, is indicative of the scale of the impact of dredging on seagrasses. In recent years, tighter control in the form of strict regulations, proper enforcement and monitoring, and mitigating measures together with proper impact assessment and development of new environmental dredging techniques help to prevent or minimize adverse impacts on seagrasses. Costs of such measures are difficult to estimate, but seem negligible in comparison with cost of seagrass restoration programs, which are typically small-scale in approach and often have limited success. Copying of dredging criteria used in one geographic area to a dredging operation in another may in some cases lead to exaggerated limitations resulting in unnecessary cost and delays in dredging operations, or in other cases could prove damaging to seagrass ecosystems. Meaningful criteria to limit the extent and turbidity of dredging plumes and their effects will always require site-specific evaluations and should take into account the natural variability of local background turbidity.

Comments: Not applicable

Erftemeijer, P.L.A. 2006. Managing the effects of dredging on seagrasses in the Mediterranean Sea. *Biologia Marina Mediterranea* 13 (4): 183-188.

Sampling or Data Summary Period: Literature review (1980-2005)

Publication Type: Peer-review journal

Abstract: A concise review of the impacts of dredging and disposal of dredged material on seagrasses is presented, with a special emphasis on the Mediterranean Sea. The critical threshold of seagrasses for turbidity and sedimentation are discussed, along with four case studies of dredging impacts on seagrasses in the Mediterranean Sea (accounting for the loss of an estimated 1,450 ha). The paper concludes with an overview of mitigating measures and management options (including site-specific dredging criteria) that can be applied to control and minimize the impacts of dredging on seagrasses in the Mediterranean.

Comments: Not applicable

Fernández-Torquemada, Y., J.M. González-Correa, J.E. Martínez, and J.L. Sánchez-Lizaso. 2005. Evaluation of the effects produced by the construction and expansion of marinas on *Posidonia oceanica* (L.) Delile meadows. *Journal of Coastal Research* SI 49: 94 – 99.

Sampling or Data Summary Period: 2002-2003

Publication Type: Peer-review journal

Abstract: New legislation in the Valencian Community (Decree 36/2002, 5th of March) has allowed the expansion of the existent marinas in this region of the SE of Spain, affecting in a significant way the Alicante province that possesses over thirty nautical facilities of this type. Of particular importance are the effects that expansion of these ports would have on marine ecosystems, especially on *Posidonia oceanica* beds. This species is of great ecological and biological importance, and is very sensitive to human activities along the coastline. The present study focuses on the current impacts and potential impacts of port extension of the Port of Altea and the Marina Luis Campomanes (NE Alicante) on the existing *P. oceanica* meadows near them. Density, cover, morphology and phenology of *P. oceanica* growing close to the ports were compared with adjacent control sites. The present ports have caused the destruction of at least 11 Ha of *Posidonia* meadow and the degradation of another 14 Ha where it has been detected an important reduction of its cover and density, and an increase in rhizome growth, the herbivore rate and the load of epiphytes of its leaves. Furthermore the analysis of all these data have also allowed to determine that the outer expansion of both ports would cause the disappearance of 64 Ha and the regression of 18 Ha of *P. oceanica* meadows.

Comments: Not applicable

Gordon, D.M., P. Collins, I.N. Baxter and I. LeProvost. 1996. Regression of seagrass meadows, changes in seabed profiles and seagrass composition at dredge and undredged sites in the Owen Anchorage Region of south-western Australia. In Kuo, J., R.C. Phillips, D.I. Walker, and H. Kirkman (eds.), *Seagrass Biology: Proceedings of an International Workshop*. Rottneest Island, Western Australia, 25-29 January 1996. pp. 323-332.

Sampling or Data Summary Period: 1991-1995

Publication Type: Peer-review journal

Abstract: Seventeen transects were installed on the seafloor in the Owen Anchorage region of south-western Australia between 1991 and 1994 to document annual changes in seabed profiles and the extent of regression of seagrass meadows on shallow banktops next to dredged slopes on two dredged channels. Changes in the composition of seagrass species along the transects were also recorded. Findings are presented for six longer established transects, which illustrate the changes occurring at sites with differing histories of dredging. Seabed profiles changed only at recently dredged sites, where seagrasses on the banktops regress up to several meters per year. On older and shallower slopes

there was no change in the profiles and no evidence of regression. The findings are consistent with the hypothesis that meadow regression next to dredged slopes stops once the slopes mature and attain a stable angle of repose. Several seagrasses have colonized dredged slopes and channel floors to varying degrees, including three species of *Posidonia*, *Amphibolis graffithii*, two species of *Halophila* and *Heterozostera tasmanica*. The persistence, structure and dynamics of these colonizing seagrasses have yet to be investigated; however, these early observations suggest that deeper, dredged areas are capable of supporting seagrasses, albeit of differing composition and biomass to those on the banktop.
Comments: Not applicable

Hellier, T.R. and L.S. Kornicker. 1962. Sedimentation from a hydraulic dredge in a bay. Publications of the Institute of Marine Science 8: 212-215.

Sampling or Data Summary Period: 1958-1960

Publication Type: Peer-review journal

Abstract: Red gravel was used to mark the bay sediment surface at five stations in turtle grass flats near Aransas Pass, Texas prior to the dredging of an intracoastal waterway. Cores were taken and sediments were studied before, one week after dredging, and 18 months later. 22 to 27 cm of sediment (11 to 55% silt-clay) were deposited within 0.5 mile of the dredge, but effects at greater distance were negligible. Little sediment sorting was observed during dredging.

Comments: Not applicable

Kirsch, K.D., K.A. Barry, M.S. Fonseca, P.E. Whitfield, S.R. Meehan, W.J. Kenworthy, and B.E. Julius. 2005. The Mini-312 Program – an expedited damage assessment and restoration process for seagrasses in the Florida Keys National Marine Sanctuary. Journal of Coastal Research SI 40: 109-119.

Sampling or Data Summary Period: 2000-2005

Publication Type: Peer-review journal

Abstract: There are approximately 650 known vessel groundings that occur annually within the Florida Keys National Marine Sanctuary (FKNMS). The majority of these groundings directly impact valuable seagrass habitat. The National Oceanic and Atmospheric Administration (NOAA), under the National Marine Sanctuary Act, and the State of Florida, under Florida statutes, act as co-trustees with the authority to recover monetary damages and restore injuries to the natural resources of the FKNMS. Previously, it was difficult to accomplish assessment and restoration planning for many of these incidents in a cost-effective manner. With the goal of expediting development of litigation-quality natural resource damage claims for seagrass grounding incidents, NOAA has developed and implemented standardized damage assessment, restoration planning, and restoration scaling protocols for seagrass injuries. The protocols center around three major components: 1) GIS-based field assessment, 2) model-based estimation of injury recovery rates, and 3) calculation of compensation using Habitat Equivalency Analysis. By standardizing the assessment and restoration planning procedures associated with these types of incidents, NOAA and the State of Florida have substantially lowered the threshold for the size and severity of grounding injuries that can be cost-effectively assessed and restored, significantly increasing the number of cases that can be addressed annually. In addition to the direct resource benefits of increased assessment and restoration, we anticipate that there will also be a deterrent effect on future groundings.

Comments: Not applicable

Livingston, R.J. 1987. Historic Trends of human impacts on seagrass meadows in Florida. In Durako, M.J., R.C. Phillips and R.R. Lewis, III (eds.). Proceedings of the Symposium on Subtropical-Tropical Seagrasses of the Southeastern United States: 12 August 1985. Florida Marine Research Publications. Number 42: 139-151.

Sampling or Data Summary Period: 1960-1985

Publication Type: Peer-review journal

Abstract: Seagrass meadows are highly productive areas that provide food and habitat for diverse species. Seagrass systems predominate in shallow marine areas along the southeast and west coast of Florida. These systems support important sports and commercial fisheries. Since 1940, Florida has undergone unprecedented population growth, which is expected to accelerate into the next century. Municipalization, industrialization, and agricultural activities in coastal drainage systems have been accompanied by various impacts in almost every bay system in Florida. Seagrass meadows have been virtually eliminated in most portions of the Pensacola Bay and Tampa Bay systems. Significant losses have been noted over the past 20-40 years in Choctawhatchee Bay, Apalachee Bay, Charlotte Harbor, Biscayne Bay, and Indian River. A lack of reliable data precludes appropriate evaluations in other areas. However, the two primary concentrations of seagrasses in the northern hemisphere, Florida Bay and the northwest Gulf coast (including Apalachee Bay), are currently threatened by wide-ranging forms of human activity, which include freshwater diversion, agriculture activities, dredging, and offshore oil drilling. The general lack of long term, multidisciplinary ecological studies has inhibited a thorough understanding of the problem. Recent studies in Apalachee Bay indicate that relatively minor water-quality changes can destroy or severely alter seagrass distribution and productivity. Recovery after impact appears to be slow. Land planning and resource management efforts to protect seagrass habitats have been either lacking or largely ineffectual in the state as a whole. In some areas, such as the Apalachicola estuary, a comprehensive research and management effort has been developed and could provide a model for future planning in Florida, although the long-term effectiveness of such programs remains untested. Nevertheless, in a few decades, human activities have eliminated significant proportions of existing seagrass meadows in Florida. Based on past encroachment and projected population increases, the outlook for remaining seagrass beds is bleak.

Comments: Not applicable

Long, B.G., D.M. Dennis, T.D. Skewes, and I.R. Poiner. 1996. Detecting an environmental impact of dredging on seagrass beds with a BACIR sampling design. Aquatic Botany 53: 235-243.

Sampling or Data Summary Period: 1991-1993

Publication Type: Peer-review journal

Abstract: The impact of maintenance dredging an access channel to a canal estate in Deception Bay, Australia, on the nearby seagrasses was monitored over 18 months with a Before/After Control/Impact, Repeated measures (BACIR) sampling design. Three seagrasses were collected in the study area; *Zostera capricorni* Aschers., *Halophila ovalis* (R.Br.) Hook. f. and *Halophila spinulosa* (R.Br.) Aschers. All seagrasses were found less than 700 m offshore. The biomass of *Z. capricorni*, the numerically dominant seagrass, was significantly lower in the access channel border compared with the control area before dredging, which was attributed to direct or indirect effects associated with the channel. There was no significant effect of maintenance dredging statistically detected for *Z. capricorni* biomass in the access channel border even though seagrass was absent in the access channel 14 months after dredging. This was due to the high background variability of seagrass biomass in the control area. In contrast the biomass of *H. ovalis* declined at a significantly higher rate in the control area than in the access channel border but had also disappeared from the access channel border 14 months after

dredging. Without a control we may have concluded that the disappearance of seagrass from the access channel border was due to the effects of dredging, whereas with a BACIR sampling program there remained a possibility that the decline in seagrass was due to larger scale changes in the bay.

Comments: Not applicable

Odum, H.T. 1963. Productivity measurements in Texas turtle grass and the effects of dredging in an intracoastal channel. Publications of the Institute of Marine Science 9: 48-58.

Sampling or Data Summary Period: 1957-1962

Publication Type: Peer-review journal

Abstract: Measurements of benthic chlorophyll "A" and diurnal oxygen productivity were made in turtle grass beds containing *Thalassia testudinum* and *Diplanthera wrightii* in Redfish Bay, Texas, before and after the dredging of an intracoastal canal. Moderate values of photosynthesis 2 to 8 g O₂/m² per day were observed in the spring of 1959 following a period of shading by turbid dredge-waters, but exceptionally high values 12 to 38 g/m² per day were recorded the following spring in those areas not smothered with silt. Chlorophyll "A" in the 1959 averaged 0.0338 g/m² but increased to 0.68 g/m² the following summer.

Comments: Not applicable

Onuf, C.P. 1994. Seagrasses, dredging and light in Laguna Madre, Texas, U.S.A. Estuarine, Coastal and Shelf Science 39: 75-91.

Sampling or Data Summary Period: 1965-1990

Publication Type: Peer-review journal

Abstract: Light reduction resulting from maintenance dredging was the suspected cause of large-scale loss of seagrass cover in deep parts of Laguna Madre between surveys conducted in 1965 and 1974. Additional changes to 1988, together with an analysis of dredging frequency and intensity for different parts of the laguna, were consistent with this interpretation. Intensive monitoring of the underwater light regime and compilation of detailed environmental data for 3 months before and 15 months after a dredging project in 1988 revealed reduced light attributable to dredging in four of eight subdivisions of the study area, including the most extensive seagrass meadow in the study area. Dredging effects were strongest close to disposal areas used during this project but still were detectable on transects >1.2 km from the nearest dredge disposal area. In the subdivision of the study area where most of the dredge disposal occurred, light attenuation was increased throughout the 15 months of observation after dredging. In the seagrass meadow and the transition zone at the outer edge of the meadow, effects were evident up to 10 months after dredging. Resuspension and dispersion events caused by wind-generated waves are responsible for the propagation of dredge-related turbidity over space and time in this system.

Comments: Not applicable

Pulich, W.M. and W.A. White. 1991. Decline of submerged vegetation in the Galveston Bay system: Chronology and relationships to physical processes. Journal of Coastal Research 7(4): 1125-1138.

Sampling or Data Summary Period: 1950-1990

Publication Type: Peer-review journal

Abstract: Changes in submerged vascular plant distribution since the 1950's were documented for the Galveston Bay system (excluding the Trinity River delta proper) using aerial photographs and substantiated field reports. Two major regions where seagrasses have declined extensively were compared with nearby sites where vegetation persists. Along the upper bay shoreline, evidence is presented for involvement of Hurricane Carla (1961) and a relative rise in sea level due to subsidence, which resulted in the disappearance of *Ruppia maritima* beds between 1960 and 1962. In the lower bay (West Bay), mixed beds of *R. maritima* and *Halodule wrightii* declined steadily from the 1950's and disappeared by the early 1980's. This area contrasts with Christmas Bay, a secondary protected bay 5 to 7 km south that still contains extensive beds of *H. wrightii* and small patches of *Thalassia testudinum* and *Halophila engelmanni*. In West Bay, urban development, wastewater discharges, chemical spills, and dredging activities, rather than subsidence and Hurricane Carla, are suspected as the principal deleterious agents. Similarities between submerged vegetation declines in Galveston and other bay systems are discussed,

Comments: Not applicable

Sabol, B., D. Shafer, and E. Lord. 2005. Dredging effects on eelgrass (*Zostera marina*) distribution in a New England small boat harbor. Dredging Operations and Environmental Research Program. U.S. Army Corps of Engineers. ERDC/EL TR-05-8.

Sampling or Data Summary Period: 2001-2004

Publication Type: Technical report

Abstract: While speculation on effects of dredging on seagrass beds is plentiful, actual empirical data documenting these effects are not. In this study, acoustic-based seagrass mapping techniques were used to generate detailed maps of seagrass distribution before and after dredging operations. Eelgrass (*Zostera marina*) within Scituate Harbor, MA, was monitored during mid-summer in 2001, 2003, and 2004; navigation maintenance dredging of the harbor was performed during fall 2002. Similar surveys were also performed during the same timeframe at an undredged harbor near Wood Island, ME. Two types of potential impacts were examined. Direct impacts involved physical removal of vegetation along with the dredged sediments. Indirect impacts in adjacent undredged areas may occur as a result of increased turbidity and/or siltation associated with dredging activities. Using hydroacoustic techniques, the authors were able to easily map and quantify direct impacts to eelgrass resources. Assessment of indirect impacts, however, was more complex. In the first post-dredging survey, a substantial reduction in coverage occurred in adjoining undredged areas, suggesting possible indirect impacts. This was followed by a modest recovery between the first and second post-dredging years. However, monitoring of other undredged sites within the region showed natural year-to-year variations in eelgrass coverage to be almost as large as those occurring at the dredged site. Results emphasize the need for long-term data to discern any potential effects of dredging on seagrass dynamics as opposed to a host of other factors contributing to high variability in measured parameters.

Comments: Not applicable

Sheridan, P. 2004. Recovery of floral and faunal communities after placement of dredged material on seagrasses in Laguna Madre, Texas. Estuarine, Coastal and Shelf Science 59: 441-458.

Sampling or Data Summary Period: 1995-1998

Publication Type: Peer-review journal

Abstract: The objectives of this project were to determine how long alterations in habitat characteristics and use by fishery and forage organisms were detectable at dredged material placement sites in Laguna Madre, Texas. Water, sediment, seagrass, benthos, and nekton characteristics were measured and compared among newly deposited sediments and nearby and distant seagrasses each fall and spring over three years. Over this period, 75% of the estimated total surface area of the original deposits was either re-vegetated by seagrass or dispersed by winds and currents. Differences in water and sediment characteristics among habitat types were mostly detected early in the study. There were signs of steady seagrass re-colonization in the later half of the study period, and mean seagrass coverage of deposits had reached 48% approximately three years after dredging. Clovergrass *Halophila engelmannii* was the initial colonist, but shoalgrass *Halodule wrightii* predominated after about one year. Densities of annelids and non-decapod crustaceans were generally significantly greater in close and distant seagrass habitats than in dredged material habitat, whereas densities of mollusk were not significantly related to habitat type. Nekton (fish and decapod) densities were almost always significantly greater in the two seagrass habitats than in dredged material deposits. Benthos and nekton communities in dredged material deposits were distinct from those in seagrass habitats. Recovery from dredged material placement was nearly complete for water column and sediment components after 1.5-3 years, but recovery of seagrasses, benthos, and nekton was predicted to take 4-8 years. The current 2 to 5 year dredging cycle virtually insures no time for ecosystem recovery before being disturbed again. The only way to ensure permanent protection of the high primary and secondary productivity of seagrass beds in Laguna Madre from acute and chronic effects on maintenance dredging, while ensuring navigation capability, is to remove dredged materials from the shallow waters of the ecosystem.

Comments: Not applicable

Short, F.T. and S. Wyllie-Echeverria. 1996. Natural and human-induced disturbance of seagrass. Environmental Conservation 23(1): 17-27.

Sampling or Data Summary Period: 1970-1994

Publication Type: Peer-review journal

Summary: Many natural and human-induced events create disturbances in seagrasses throughout the world, but quantifying losses of habitat is only beginning. Over the last decade, 90,000 ha of seagrass loss have been documented although the actual area lost is certainly greater. Seagrasses, an assemblage of marine flowering plant species, are valuable structural and functional components of coastal ecosystems and are currently experiencing world-wide decline. This group of plants is known to support a complex trophic food web and a detritus-based food chain, as well as to provide sediment and nutrient filtration, sediment stabilization, and breeding and nursery areas for finfish and shellfish.

We define disturbance, natural or human-induced, as any event that measurably alters resources available to seagrasses so that a plant response is induced that results in degradation or loss. Applying this definition, we find a common thread in many seemingly unrelated seagrass investigations. We review reports of seagrass loss from both published and 'grey' literature and evaluate the types of disturbances that have caused seagrass decline and disappearance. Almost certainly more seagrass has been lost globally than has been documented or even observed, but the lack of comprehensive monitoring and seagrass mapping makes an assessment of true loss of this resource impossible to determine.

Natural disturbances that are most commonly responsible for seagrass loss include hurricanes, earthquakes, disease, and grazing by herbivores. Human activities most affecting seagrasses are those which alter water quality or clarity: nutrient and sediment loading from runoff and sewage disposal,

dredging and filling, pollution, upland development, and certain fishing practices. Seagrasses depend on an adequate degree of water clarity to sustain productivity in their submerged environment. Although natural events have been responsible for both large-scale and local losses of seagrass habitat, our evaluation suggests that human population expansion is now the most serious cause of seagrass habitat loss, and specifically that increasing anthropogenic inputs to the coastal oceans are primarily responsible for the world-wide decline in seagrasses.

Comments: Not applicable

Taylor, J.L. and C.H. Saloman. 1968. Some effects of hydraulic dredging and coastal development in Boca Ciega Bay, Florida. Fishery Bulletin 67(2): 213-241.

Sampling or Data Summary Period: 1963-1964

Publication Type: Peer-review journal

Abstract: Filling of 1,400 hectares (3,500 acres) of bay by hydraulic dredging has reduced the area of Boca Ciega Bay, Fla., by about 20 percent since 1950. An estimate of the annual standing crop destroyed is 1,133 metric tons (798 kg. per hectare, dry whole weight) of sea grass and about 1,812 metric tons (1,277 kg. per hectare, dry weight) of associated infauna. In terms of annual production, the loss of biological resources is far greater—minimum estimates are 25,841 metric tons of sea grass, 73 metric tons of fishery products, and 1,091 metric tons of infauna exclusive of meiofauna. Natural areas remaining in the Bay support local and offshore fisheries and are of value for recreation, public utilities, commerce, and industry. At an estimated value of \$988 per hectare per year, worth of the estuarine area already eliminated is \$1.4 million annually. In addition, inestimable secondary losses occur, principally from sedimentation, turbidity and domestic sewage.

Comments: Not applicable

3.4.2 Seagrass Annotated Bibliography

Eleuterius, L.N. 1971. Submerged plant distribution in Mississippi Sound and adjacent waters. *Journal of the Mississippi Academy of Sciences* XVII: 9-14.

Sampling or Data Summary Period: 1969-1970

Publication Type: Peer-review journal

Abstract: Submerged attached plant communities of higher vascular plants and algae in Mississippi Sound were located and mapped. Vegetation covers about 4.6% of the bottom. Most of the 20,000 acres (8,093 hectares) located in 1969 were immediately north of the barrier islands. Hurricane Camille denuded about 6,000 acres (2,428 hectares) in 1969. In 1970, denuded areas showed signs of reestablishment, and plants in protected areas were more vigorous, than observed in 1969. The submerged vegetation included the "sea grasses": *Thalassia testudinum*; *Diplanthera wrightii* (*D. beaudettei*); *Cymodocea manatorum*; *Halophila engelmannii*, and numerous marine algal species. No attached plants were found south of the barrier islands; however, *Ruppia maritima*, a brackish water species, was noted in ponds and lagoons on the barrier islands and in adjacent mainland bays, rivers, and bayous. *Vallisneria americana*, the least salt tolerant species studied, also covers large areas of river and bayou bottoms.

Comments: Not applicable

Eleuterius, L.N. 1973. The distribution of certain submerged plants in Mississippi Sound and adjacent waters. In Christmas, J.Y., (ed.), *Cooperative Gulf of Mexico Estuarine Inventory and Study, Mississippi. Phase IV: Biology. Gulf Coast Research Laboratory. p. 191-197.*

Sampling or Data Summary Period: 1969

Publication Type: Technical report

Introduction: Mississippi Sound is a body of water with a surface area of approximately 434,447 acres (175,951 hectares) in Mississippi. Mississippi Sound extends from the mainland to the offshore barrier islands. This chain of barrier islands lies, on the average, approximately 8 miles from the mainland. Mississippi Sound is an estuarine area. Fresh water flows from four major river systems. Organic deposits extend from the mainland into the Sound, especially near the entrances to the major river systems. These organic deposits are over sand which is exposed near the islands and in some cases include shell fragment. Consequently, Mississippi Sound and the adjacent inland waters provide a variety of plant habitats which may be separated upon substrate type, salinity, depth of water, temperature and turbidity. However, many other factors obviously affect the organisms. This study was concerned with the submerged attached vegetation which includes six species of flowering plants and numerous algal species.

Comments: Not applicable

Eleuterius, L.N. and G.J. Miller. 1976. Observations on seagrasses and seaweeds in Mississippi Sound since Hurricane Camille. *Journal of the Mississippi Academy of Sciences* XXI: 58-63.

Sampling or Data Summary Period: 1969-1975

Publication Type: Peer-review journal

Abstract: The present status of seagrass and macrophytic marine algal beds as assessed by periodic surveys since Hurricane Camille is reported. Comparison of data obtained prior to the hurricane in 1969 with that of subsequent surveys indicates that in 1975 considerably less area of sea bottom is covered. Factors attributable to this loss are thought to be erosion and sedimentation directly related to Hurricane Camille and persistent low salinity water resulting from discharged flood waters. A basis for speculation on future recolonization of these marine plant habitats is given.

Comments: Not applicable

Eleuterius, L.N. 1977. The seagrasses of Mississippi. Journal of the Mississippi Academy of Sciences XXII: 57-79.

Sampling or Data Summary Period: Literature review (1954-1976)

Publication Type: Peer-review journal

Abstract: The salient biological features of the four local species of seagrass are reviewed from the literature to assess the present status of knowledge. Chemical, productivity and decompositional aspects are included. New information is presented on the reproductive biology, productivity, culture and salinity tolerance with notes on the present local distribution of seagrasses. Compared to other flowering plants, seagrasses are poorly understood. *Thalassia testudinum* (turtle grass) has been studied in more detail than *Halodule beaudettei* (shoal grass), *Cymodocea filiformis* (manatee grass) or *Halophila engelmannii*. Most work on *T. testudinum* has been on morphology, productivity and decomposition. Major factors affecting the distribution of seagrasses are also explored and synthesized as they relate to conditions in Mississippi waters.

Comments: Not applicable

Eleuterius, L.N. 1987. Seagrass ecology along the coast of Alabama, Louisiana, and Mississippi. In Durako, M.J., R.C. Phillips, and R.R. Lewis, III (eds.), Proceedings of the Symposium on Subtropical- tropical Seagrasses of the Southeastern United States. Florida Marine Research Publications Number 42. St. Petersburg, August 12, 1985. p. 11-24.

Sampling or Data Summary Period: Literature review (1954-1985)

Publication Type: Peer-review journal

Abstract: The seagrasses *Thalassia testudinum* Banks ex König (turtle grass), *Syringodium filiforme* Kützing (manatee grass), *Halodule wrightii* Ascherson (shoal grass), and *Halophila engelmannii* Ascherson occur in greatest abundance 30 to 50 miles offshore of Louisiana, east of Chandeleur Island, and 8 to 12 miles off the mainland shore of Mississippi, north of Horn and Petit Bois Islands. These species characteristically occupy sandy bottoms in estuarine and marine waters (20-30 ‰). Only *Halodule* is presently known to occur in Alabama waters. *Ruppia maritima* L. (widgeon grass) occurs on muddy bottoms, in waters of relatively low salinity (2-10 ‰), in bays, bayous, and river mouths along mainland Alabama, Louisiana, and Mississippi, and in tidal lagoons and certain ponds that are infrequently flooded on the barrier islands. It often grows associated with *Vallisneria*, *Najas*, *Zannichellia*, and other freshwater aquatics. Hurricanes have eroded or buried in sand thousands of acres of seagrass beds near the offshore barrier islands. Freshwater discharges through the Bonnet Carré Spillway have also contributed to the loss of *Thalassia*, *Syringodium*, *Halodule*, and *Halophila*. However, because of its tolerance to brackish waters, *Ruppia* has spread over a greater portion of the local bay, bayou, and river bottoms. During years when optimum conditions for growth occurred in Mississippi Sound, average short-shoot densities were 720 m⁻² for *Thalassia* (range: 80 to 1200 m⁻²), 400 m⁻² for *Syringodium* (range: 150 to 1600 m⁻²), and 2400 m⁻² for *Halodule* (range: 300 to 3200 m⁻²).

⁻²). Average leaf lengths were 24 cm for *Thalassia* (range: 8 to 41 cm), 43 cm for *Syringodium* (range: 18 to 65 cm), and 14 cm for *Halodule* (range: 6 to 21 cm). Biomass averaged 1100 g dwt m⁻² for *Thalassia* (range: 30 to 3200 g dwt m⁻²), with a shoot-to-rhizome-and-root ratio of 1:4. *Syringodium* biomass averaged 250 g dwt m⁻² (range: 20 to 650 g m⁻²), with a shoot-to-rhizome-and-root ratio of 1:2. *Halodule* biomass averaged 138 g dwt m⁻² (range: 30 to 870 g dwt m⁻²), but in this species, biomass and leaf length increase with distance from shore and water depth, while shoot density decreases. In each species, biomass varies seasonally, annually, and between beds, and continuous movement of sand bars affects leaf length, shoot density, and biomass. In 1968, a period of prolonged, extremely high salinity, epiphytic algae and bryozoans accounted for 70% of the total biomass of certain deepwater seagrass beds. During this same period, about 100 species of marine invertebrates were found in seagrass beds in Mississippi Sound. *Thalassia* beds had the largest number of animal species (59), with 20 species found there exclusively. In contrast, during a period of prolonged low salinity in 1973, only 63 animal species were found among all beds. Catastrophic death of marine invertebrates and vertebrates (seahorses) occurs when massive amounts of fresh water are discharged during periodic openings of the Bonnet Carré Spillway. Transplanting of seagrass, using coated metal anchors, has been very successful with *Halodule*. Some beds of *Thalassia* have been established, but no *Syringodium* transplants have survived. Information is seriously lacking concerning all aspects of seagrass biology and ecology for the Alabama, Louisiana, and Mississippi coastal region; less than two dozen reports or papers currently exist.

Comments: Not applicable

Heck, K.L., M.J. Sullivan, J.M. Zande, and C.A. Moncreiff. 1996. An ecological analysis of seagrass meadows of the Gulf Islands National Seashore, years one, two, and three: seasonal assessment and inventory, interaction studies and assessment/inventory. Final report to the National Park Service, Gulf Islands National Seashore. 379 pp.

Sampling or Data Summary Period: 1994-1996

Publication Type: Technical report

Summary: The primary purpose of this study was to conduct a quantitative ecological analysis of the seagrass ecosystems of the Gulf Islands National Seashore (GUIS) so that these seagrass resources can be managed effectively. The GUIS seagrass ecosystems have been, and are currently threatened by the cumulative effects of encroaching residential and industrial development, as well as by natural impacts such as hurricanes. This 3 year study was designed to provide a quantitative baseline characterization of seagrass ecosystem status and a detailed understanding of the functional ecology of the major system components. Based on the results of this study, recommendations for a long-term monitoring program are provided that will allow resource managers to remain aware of the changes taking place in GUIS and, consequently, to make appropriate management decisions.

Comments: Not applicable

Humm, H.J. 1956. Sea grasses of the northern Gulf Coast. Bulletin of Marine Science of the Gulf and Caribbean 6(4): 305-308.

Sampling or Data Summary Period: 1950-1955

Publication Type: Peer-review journal

Abstract: On the basis of observations in Mississippi Sound and elsewhere, it is known that at least five species of marine monocotyledonous plants commonly known as "sea grasses" occur in abundance

along the northern Gulf coast and may be virtually continuous between Florida and Aransas, Texas. An annotated list of species and key are included.

Comments: Not applicable

Moncreiff, C.A., T.A. Randall, and J.D. Caldwell. 1998. Mapping of seagrass resources in Mississippi Sound. Final Report to Mississippi Department of Marine Resources. 41 pp.

Sampling or Data Summary Period: 1995-1998

Publication Type: Technical report

Abstract: The current and historical distributions of seagrasses in Mississippi Sound were mapped to provide a usable form of baseline information for this valuable marine resource. Seagrass distributions from a 1969 Gulf of Mexico estuarine inventory were used as a source of historical documentation, while data from a 1992 National Biological Service aerial imagery study were ground-truthed to provide recent distribution patterns. Potential seagrass habitat was also identified using a 2 meter critical depth limit which has been previously established by Heck et al. (1994, 1996) in a National Park Service seagrass monitoring project. The continued survival and growth of seagrasses may be threatened by the cumulative effects of anthropogenic activities in the coastal marine environment, which include commercial and recreational use of seagrass habitat, in addition to a number of other uses which may directly or indirectly impact seagrasses. The primary vector for the disappearance of seagrasses is presently thought to be an overall decline in water quality, which may have a deleterious effect on certain species of seagrasses. Detailed maps of extant seagrasses and potential seagrass habitat are critical because of the importance of seagrasses as nursery habitat for larval and juvenile stages of fish and invertebrates, many of which are economically important. Because seagrasses and their associated microalgae function as both habitat and food for organisms such as penaeid shrimp and blue crabs, in addition to many non-commercial species that often directly or indirectly support commercial fisheries, it is imperative that we elucidate how these critical habitats function. The maps generated from this study were used to compare the historical extent of the seagrass communities with present day coverage. This baseline information is intended to aid resource managers and scientists in recognizing and interpreting the effects of potential degrading impacts on the seagrasses and to lead to informed decisions regarding the management of this marine resource.

Comments: Not applicable

Moncreiff, C.A. 2007. Statewide summary for Mississippi. In Handley, L., D. Altzman, and R. DeMay (eds.). Seagrass Status and Trends in the Northern Gulf of Mexico: 1940-2002. U.S. Geological Survey Scientific Investigations Report 2006-5287 and U.S. Environmental Protection Agency 855-R-04-003. p. 73-76.

Sampling or Data Summary Period: 1940-2002

Publication Type: Technical report

Summary: Although the coastline of Mississippi spans only 113 linear kilometers (70 mi), the estuaries within its borders constitute a much larger area, roughly 594 km (369 mi). The primary body of water within the state's boundaries that supports seagrasses is Mississippi Sound, which covers 175,412 ha (433,443 acres) at mean low tide. This body of water is immediately bounded by the coast of Mississippi to the north; Mobile Bay, Ala., to the east; a series of barrier islands that make up most of the Gulf Islands National Seashore to the south; and Lake Borgne, La., to the west. Areas that support seagrasses within Mississippi's coastal waters include the Gulf Islands National Seashore (GINS), specifically Ship, Horn, and Petit Bois Islands, and Cat Island, which was partially purchased as an

addition to the GINS. Two additional areas along the immediate coast, one at the margins of the Grand Bay National Estuarine Research Reserve at the eastern boundary of the state and the other at the western edge adjacent to Buccaneer State Park, complete the list of estuarine and marine areas within the state that support seagrasses. All of these areas fall within the boundaries of a single water body, the Mississippi Sound. Recent estimates of seagrass coverage based on 1992 aerial imagery indicate that only 3% of the bottom of Mississippi Sound supports seagrass, with a total of 809 ha (1999 acres) of seagrass, despite the sound having an average depth of 2 m (6 ft) and approximately 6,000 ha (14,826 acres) that is believed to be capable of supporting seagrasses. This 1992 estimate of seagrass coverage represents a substantial loss in cover when compared to previous 1969 estimates of 5,254 ha (12,983 acres) of seagrasses.

Comments: Not applicable

Moncreiff, C.A. 2007. Mississippi Sound and the Gulf Islands. In Handley, L., D. Altsman, and R. DeMay (eds.). Seagrass Status and Trends in the Northern Gulf of Mexico: 1940-2002. U.S. Geological Survey Scientific Investigations Report 2006-5287 and U.S. Environmental Protection Agency 855-R-04-003. p. 77-86.

Sampling or Data Summary Period: 1940-2002

Publication Type: Technical report

Summary: Seagrasses in Mississippi Sound were likely first documented by H.J. Humm (1956), though there are earlier descriptions of marine angiosperms associated with the barrier islands of Louisiana and Mississippi (Lloyd and Tracy, 1901). Prior to Humm's work, it was believed that seagrasses, with the exception of wigeon grass (*Ruppia maritima*), occurred only very rarely between Bay County, Fla., and Aransas County, Tex. (Thorne, 1954). Humm (1956) described extensive beds of seagrasses along the northern margins of Mississippi's barrier islands, dominated by turtle grass (*Thalassia testudinum*), and indicated that turtle grass was the dominant seagrass in Mississippi Sound. He also documented the presence of manatee grass (*Syringodium filiforme*), shoal grass (*Halodule wrightii*), and star grass (*Halophila engelmannii*), in addition to the presence of previously reported beds of wigeon grass. Seagrasses were first mapped throughout the Mississippi Sound as a component of the Cooperative Gulf of Mexico Estuarine Inventory and Study, Mississippi, by L.N. Eleuterius between 1967 and 1969 (Christmas, 1973). All five previously mentioned seagrass species were again present and relatively abundant, though the beds of turtle grass described by Humm (1956) at Ship Island had disappeared as of March 1969 (Eleuterius, 1973); this period may have been the beginning of seagrass loss in Mississippi Sound. Stressors that might have caused seagrasses to become diminished or to disappear from Mississippi coastal regions likely resulted from the cumulative effects of human activities in the coastal marine environment. These activities include historical commercial uses and present-day recreational uses of seagrass habitat in addition to a number of other factors which may directly or indirectly impact seagrasses. Development may be a major factor, as it often results in higher sediment loads, introductions of contaminants, and elevated nutrient levels, which all can contribute to a loss of water quality, thus affecting seagrass communities.

Comments: Not applicable

Rakocinski, C.F., C.A. Moncreiff, M.S. Peterson, K.E. VanderKooy, and T.A. Randall. 2008. Habitat condition and associated macrofauna reflect differences between protected and exposed seagrass landscapes. Gulf and Caribbean Research 20: 11-19.

Sampling or Data Summary Period: 1998

Publication Type: Peer-review journal

Abstract: Seagrass landscape configurations associated with different physical settings can affect habitat-structure and plant-animal relationships. We compared shoal grass (*Halodule wrightii*) habitat and macrofaunal variables between two fragmented seagrass landscapes at barrier-island locations subject to different disturbance regimes. Five seagrass habitat variables including above ground biomass (AGB), shoot number, per shoot biomass, epiphyte biomass and below ground biomass (BGB), differed significantly between the island landscapes. Per shoot biomass and epiphyte biomass also varied significantly over the seagrass growing season; and epiphyte biomass showed a strong landscape-time interaction. Abundances of microgastropods normalized to AGB differed significantly between landscapes. An inverse relationship between the abundance of microgastropods and epiphyte loading suggests a possible functional link. However, additional temporal mismatch between epiphyte loading and microgastropod abundance indicates that controls on epiphyte loading were complex. Seagrass habitat was more fragmented within the Cat Island (CI) landscape. Wind direction and strength imply that the CI landscape experienced more physical disturbance than the Horn Island (HI) landscape. This study highlights some potential links involving landscape configuration, habitat structure, and macrofaunal associations which can be further addressed using hypothesis-driven research.

Comments: Not applicable

Richmond, E.A. 1962. The fauna and flora of Horn Island, Mississippi. Gulf Research Reports 1(2): 59-106.

Sampling or Data Summary Period: 1945-1962.

Publication Type: Peer-review journal

Summary: Recorded and listed a total of 1,100 species of animals and plants (including seagrasses) found on Horn Island.

Comments: Not applicable