GEL | Engineering LLC   ANAMAR Environmental Consulting, Inc.   WEC   problem solved

Project Status Update

Murrells Inlet Dredge

Georgetown and Horry Counties

August 18, 2022

GOAL

Obtain and maintain navigable depths (5-8 ft deep) in Murrells Inlet creeks sufficient for all tide navigation in a financially sustainable and environmentally sensitive manner.

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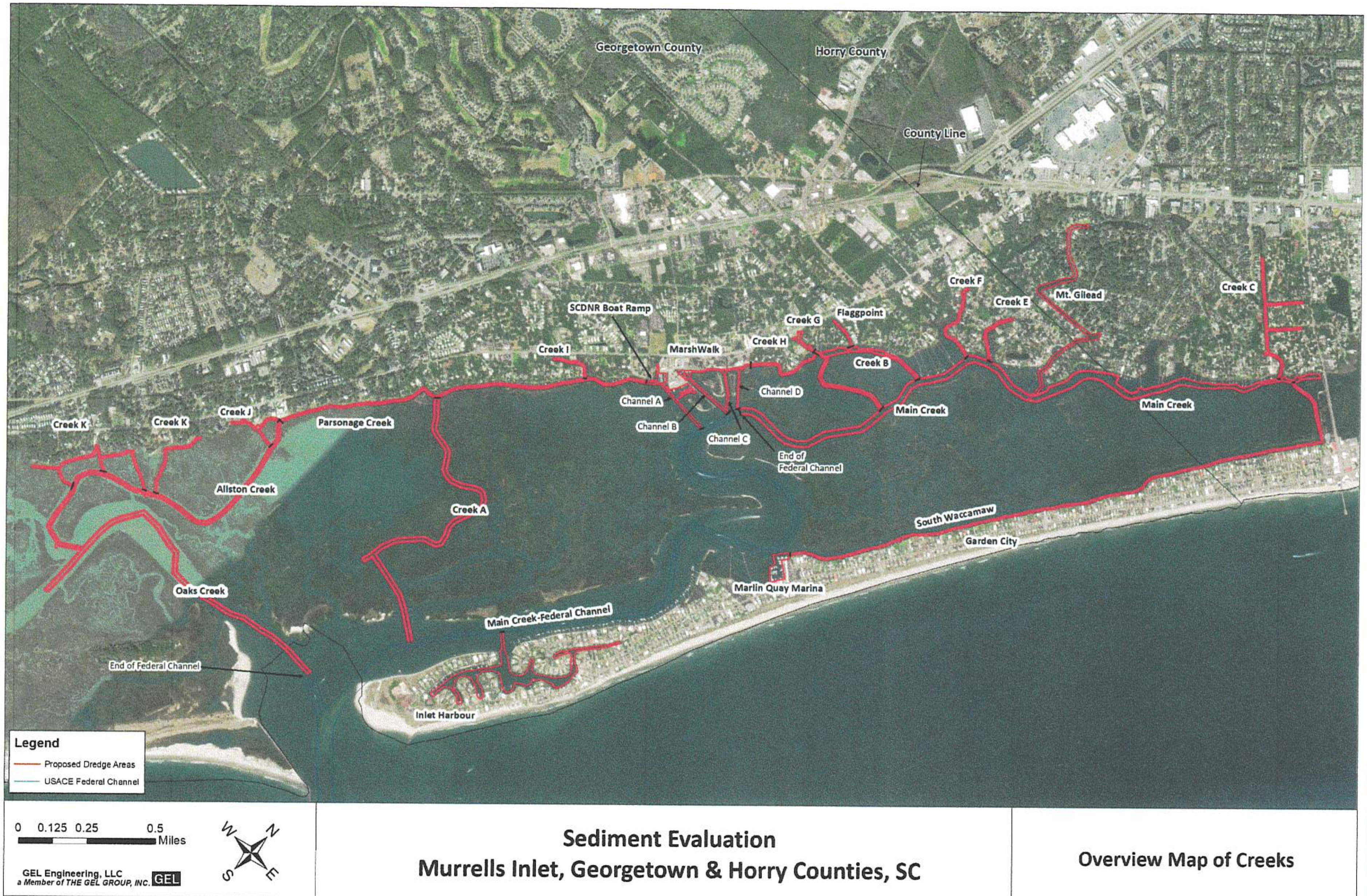
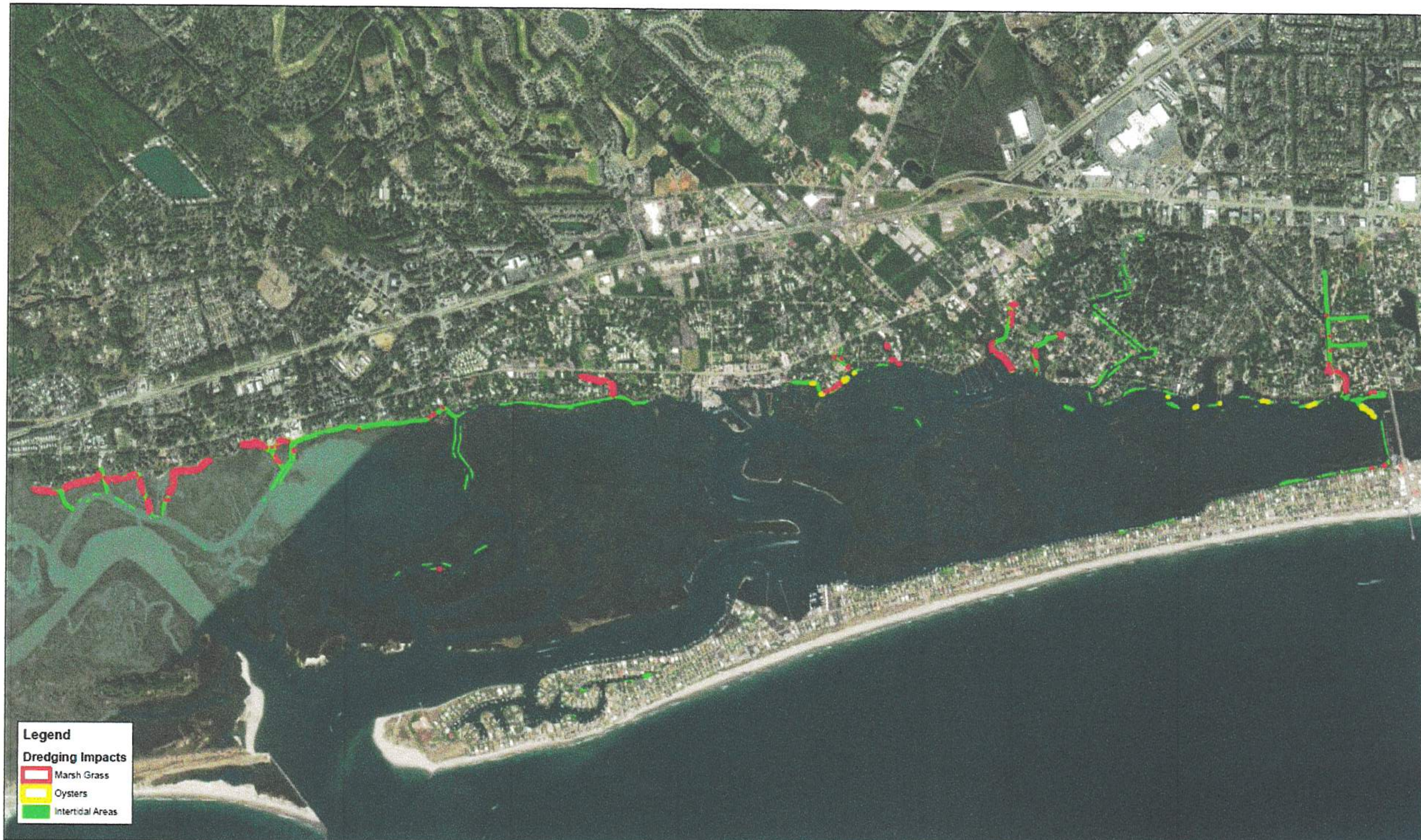


Sediment Evaluation
Murrells Inlet, Georgetown & Horry Counties, SC

Overview Map of Creeks

Project Parameters

- Ideally dredge 590,000-730,000 CY of sediment
- Achieve minimum depth of 6 ft. (590,000 CY)
- Achieve 8 ft in larger channels (730,000 CY)
- ROM Cost to Dredge=$22,500,000-$27,500,000
- ROM Cost for Mitigation=$950,000-$1,875,000
- Marshgrass-1.17 acres; Oyster Reefs-0.53 acres
- Intertidal zone mitigation (21.7 acres)?



Murrells Inlet Dredge Master Plan
Murrells Inlet, Georgetown County, SC

Overview Map of Marsh Grass, Oyster, and Intertidal Impacts

Summary of Model Findings

- Dredged sand will migrate onshore
- Dredged fines will migrate offshore
- 2% immediately disperse – negligible accumulation outside placement area
- 10-20 years to disperse from placement area
- Monitor dredge to validate findings

Corps Initial Response to Model

- Some models used not ideal for fine-grained sediments (~65% of samples)
- Concerned that solid mud could produce clay balls that migrate to beach
- Sediment could migrate into Federal Channel
- Sediments in placement area may not move

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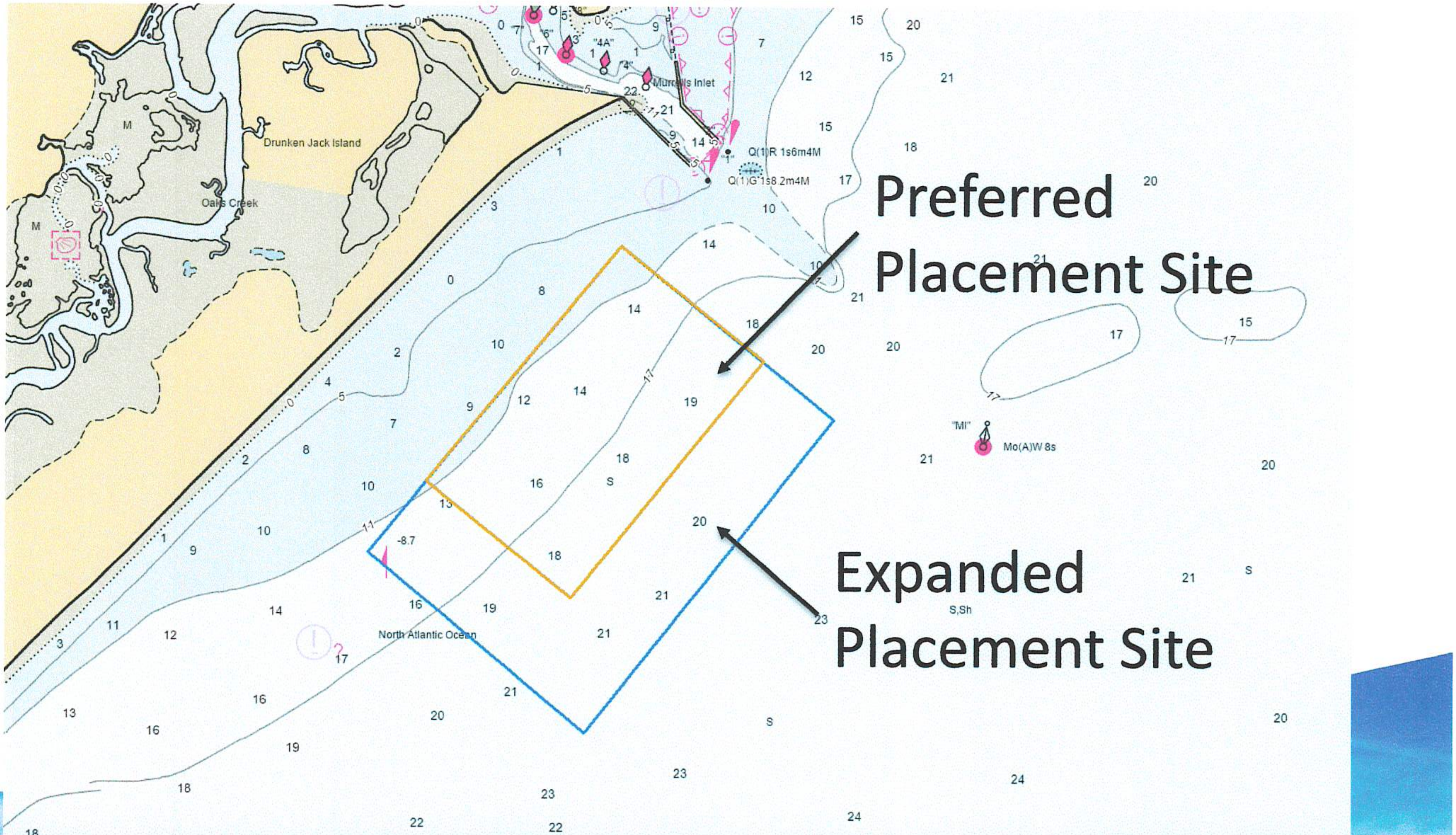
Initial Response to Corps' Concerns

- Enlarged Placement Site
- Project Team proposed additional sampling and modeling

Corps Follow-up Call – 8/11/22

- Corps approved additional sampling plan for clay ball evaluation.
- Results of additional sampling will dictate next modeling steps, if any.
  - Provided recommendations for modeling cohesive sediments, if necessary.
- Confirmed impacts to shallow subtidal/ intertidal habitat is emerging concern in region.

Preferred and Enlarged Placement Site



Nearshore Placement Site Characterization – Study Objectives

- Multibeam Survey
  - Survey the site for hardbottom resources
  - Map bathymetry of the study area
- Site Characterization Survey
  - Sediment physical and chemical characterization
  - Water quality characterization
  - Benthic/epibenthic/fish community characterization
  - Comparisons of parameters inside and outside the site
  - Provide baseline data for future (post-disposal) comparisons

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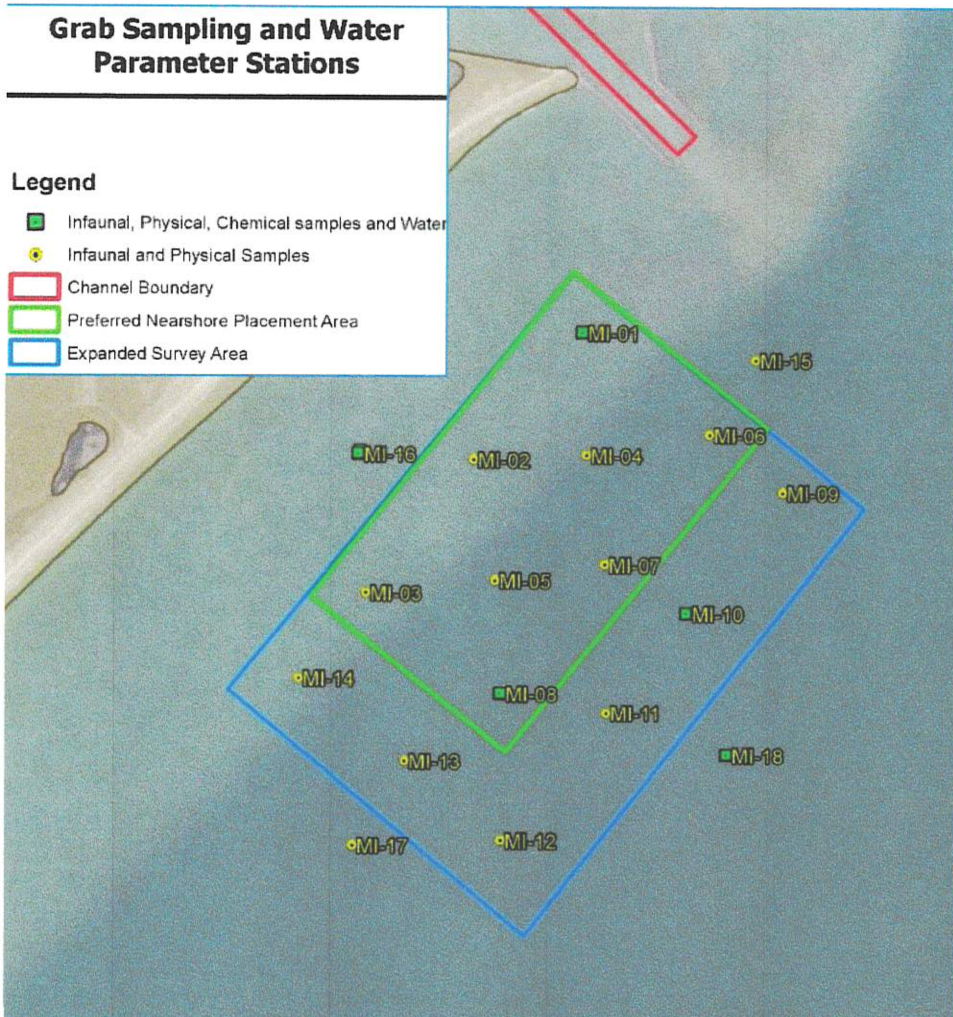
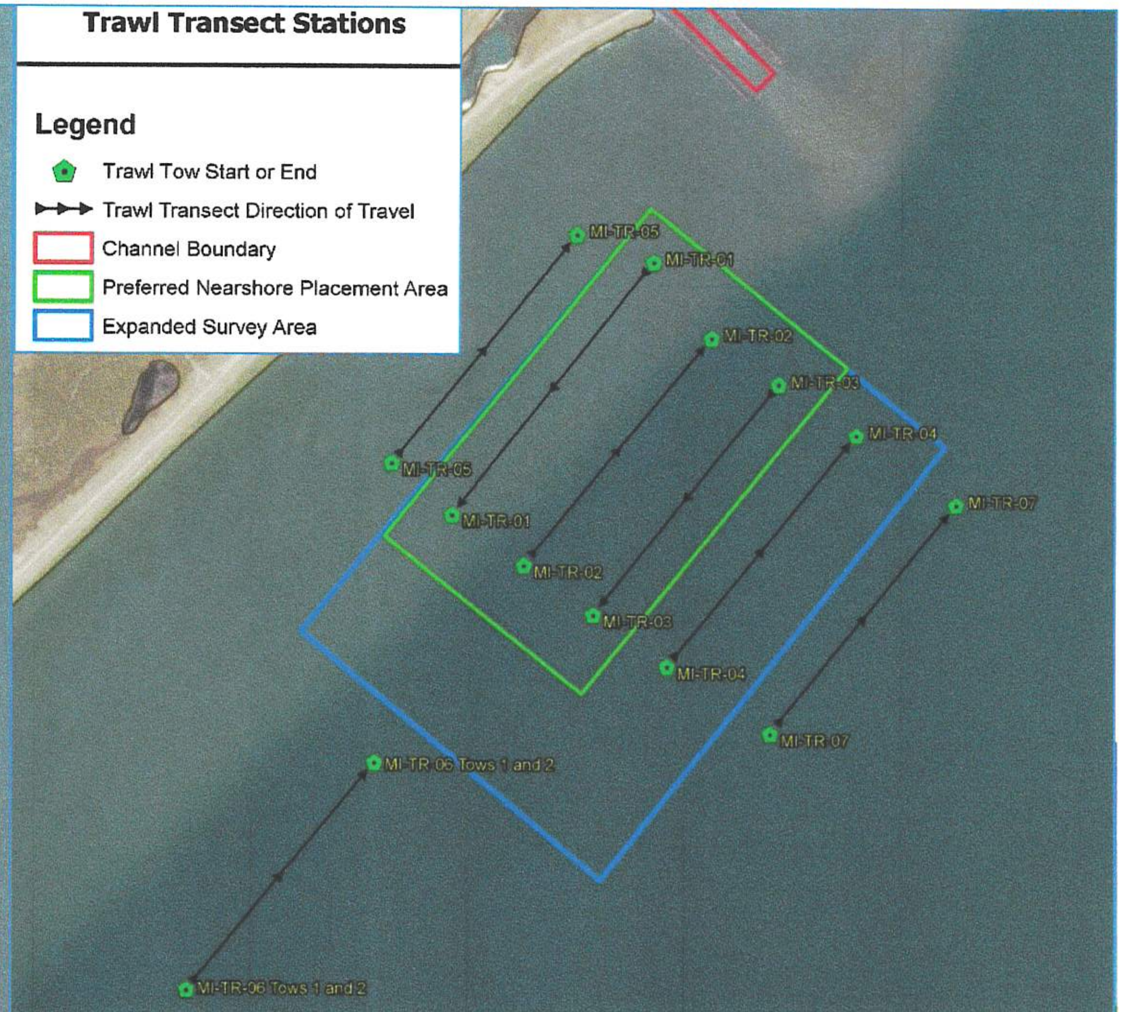
Nearshore Placement Site Characterization– Sampling Plan





Nearshore Placement Site Characterization - Conclusions

- Multibeam Survey
  - Identified no hardbottom resources
- Site Characterization Survey
  - Grain size mostly fine sand
  - Biota typical – relatively similar throughout study area
  - Sediment chemistry – typical concentrations, no threshold exceedances
  - No unique features/resources that would preclude site from being acceptable for nearshore placement.

Nearshore Placement Site Characterization– Next Steps

- Cultural Resources Survey – To be performed based on expanded survey area
- Essential Fish Habitat – Prepared, will be provided to Corps and agencies for review/comment
- Biological Assessment – Will be determined during agency coordination
- Survey of enlarged placement site

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Preliminary Dredge Plan

- Main Creek beyond Federal Channel – limited historic dredging of shoals
- Marshwalk Channels – **Routine dredging**
- Parsonage Creek – Mostly manmade - primarily excavated circa 1964
- Oaks Creek – previous dredging only near mouth
- Allston Creek – dredged only at connection with Parsonage circa 1968
- Creeks A&B – limited dredging circa 1964
- Creek C - Mostly manmade - primarily excavated circa 1950s-1970s
- Creeks E&F – Primarily manmade in existing drainage features
- Marina Colony – **Routine dredging**
- Creek H&I – Created in natural drainages
- Creek J&K – Mostly manmade - primarily excavated circa 1950s-70s
- Flaggpoint – Manmade – **dredged in 2020**
- Mt. Gilead – Excavated from highlands 1960s-70s
- South Waccamaw – Manmade circa 1951-64
- Inlet harbor/Oyster Cove – Manmade 1960s. Dredged periodically thereafter
- Marlin Quay – Manmade 1950s. **Routine dredging**

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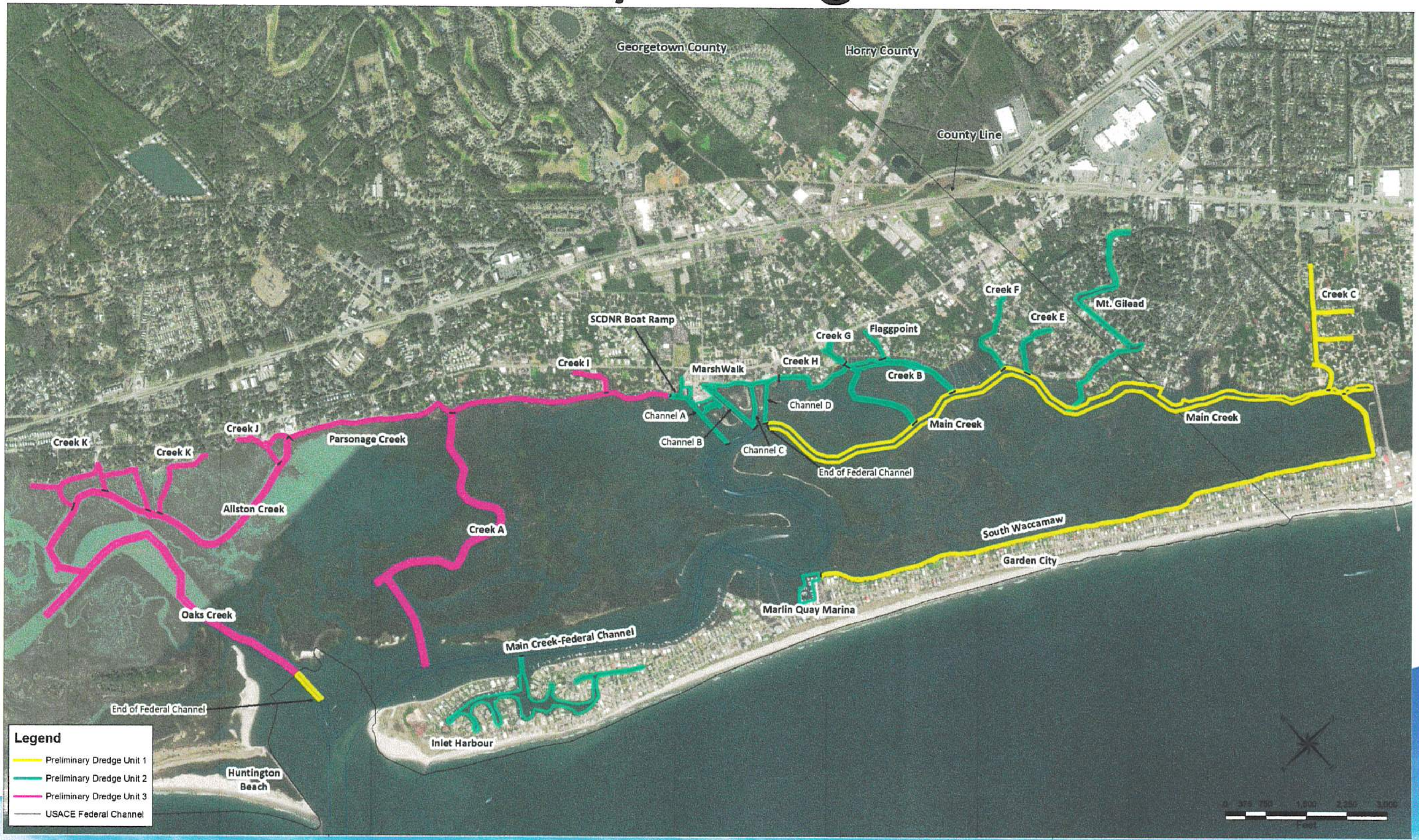
Preliminary Dredge Units



Stakeholders

- Environmental Interest Groups
  - Southern Environmental Law Center
  - South Carolina Environmental Law Project
  - Coastal Conservation League
- Huntington Beach State Park
- Businesses/Other
  - Murrells Inlet 2020
  - Marshwalk Businesses
  - Marinas
  - Dredge SW, LLC (South Waccamaw)

Stakeholders

- Homeowner Associations
  - Flaggpoint
  - Inlet Harbor
  - Marina Colony Boat Club
  - Marlin Quay
  - Mt. Gilead

RISKS

- Mitigation required for intertidal dredging (high)
- Areas considered "new work" dredging held to higher standard (high)
- Unexpected finding...cultural (low)
- Not done previously – agency reluctance and/or opposition (EPA, COE, NMF, USFW, DHEC-Water Quality, DHEC-OCRM, DNR, SHPO) (low-moderate)
- Environmental Groups/Public Opposition (moderate)
- Unworkable permit conditions (low)
- Qualified contractors (low)

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NEXT STEPS

- Have Project Update Call with Corps/EPA
- Perform Additional Sediment Sampling
- Conduct Stakeholder Outreach
- Survey of Additional Portion of Placement Site
- Perform Cultural Resources Survey of Enlarged Placement Site
- Prepare Preliminary Dredge Plan, including Adaptive Management Plan

NEXT STEPS

- Prepare Nearshore Placement Area Site Selection Document
- Submit Permit Application with Preliminary Mitigation Plan and Sediment Testing Plan for Sediment in Murrells Inlet
- Prepare for Public Feedback
- Status Meeting Update – January/February 2023

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Task Name	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23
Complete Current/Sediment Transport Modeling	X																										
Multibeam Survey			X														X										
SAP for Site-Specific Characterization Survey of ODMDS				X	X	X																					
Site-Specific Characterization Survey(s) of ODMDS									X	X	X	X															
Technical Appendices: Biological Assessment and Essential Fish Habitat Assessment									X	X	X	X															
Cultural Resources Survey																X	X										
ODMDS Selection Document																X	X										
MPRSA Section 103 Dredge Material Evaluation																						X	X	X	X	X	X
Mitigation Plan																						X	X	X	X	X	X
Comprehensive Dredging and Disposal Plan														X	X	X	X										
Permit Application																		X	X	X	X						
Agency Review/Approval							X	X																			
Dredge Contractor Selection																											
Begin Dredging																											

Task Name	Sep-23	Oct-23	Nov-23	Dec-23	Jan-24	Feb-24	Mar-24	Apr-24	May-24	Jun-24	Jul-24	Aug-24	Sep-24	Oct-24	Nov-24	Dec-24	Jan-25	Feb-25	Mar-25	Apr-25	May-25	Jun-25	Jul-25	Aug-25	Sep-25	Oct-25	Nov-25
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ODMDS Selection Document																											
MPRSA Section 103 Dredge Material Evaluation	X	X	X	X	X																						
Mitigation Plan	X	X	X	X	X	X	X																				
Comprehensive Dredging and Disposal Plan																											
Permit Application																											
Agency Review/Approval								X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
Dredge Contractor Selection								X	X	X	X	X	X	X	X	X	X	X	X	X							
Begin Dredging																											X

DRAFT

MPRSA Section 103(b) Site Selection Baseline Environmental Studies for a Proposed Siting of a Nearshore Placement Area off Murrells Inlet, Georgetown County, South Carolina: April 2022 Survey Results




Prepared by:

ANAMAR Environmental Consulting, Inc.
2106 NW 67th Place, Suite 5
Gainesville, Florida 32653

Reviewed by:

GEL Engineering, LLC
2040 Savage Road
Charleston, South Carolina 29407

Water Environment Consultants
PO Box 2221
Mount Pleasant, South Carolina 29465

On behalf of:

Georgetown County
129 Screven Street
Georgetown, South Carolina 29442

Submitted to:

U.S. Environmental Protection Agency, Region 4
61 Forsyth Street SW
Atlanta, Georgia 30303

U.S. Army Corps of Engineers, Charleston District
69A Hagood Avenue
Charleston, South Carolina 29403

July 2022

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ACRONYMS, ABBREVIATIONS, AND INITIALISMS

cy	cubic yard(s)
CZC	Coastal Zone Consistency
DDD	dichlorodiphenyldichloroethane
DDT	dichlorodiphenyltrichloroethane
DQCR	Daily Quality Control Report
EPA	U.S. Environmental Protection Agency
ERL	effects range low
GPS	global positioning system
HMW	high molecular weight (PAHs)
MLW	mean low water
LMW	low molecular weight (PAHs)
LRL	laboratory reporting limit
MDL	method detection limit
MPRSA	Marine Protection, Sanctuaries, and Research Act
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service (NMFS), aka NOAA Fisheries
nmi	nautical mile(s)
OCRM	Office of Ocean and Coastal Resource Management
ODMDS	ocean dredged material disposal site
PAH	polynuclear aromatic hydrocarbons
PCB	polychlorinated biphenyl
QA/QC	quality assurance/quality control
SAP/QAPP	Sampling and Analysis Plan/Quality Assurance Project Plan
SC DHEC	South Carolina Department of Health and Environmental Control
SC DNR	South Carolina Department of Natural Resources
SERIM	Southeastern Regional Implementation Manual (EPA and USACE 2008)
SHPO	South Carolina State Historic Preservation Office
TDL	target detection limit
TEL	threshold effects level
TOC	total organic carbon
TPH	total petroleum hydrocarbons
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
WEC	Water Environment Consultants

EXECUTIVE SUMMARY

Physical, chemical, and biological data were obtained from samples or data collected from 18 stations during the April 2022 survey. Sediment physical characteristics and benthic infaunal samples were collected from all 18 stations. Sediment chemical characteristics and water physicochemical properties were collected from five stations. Epifaunal trawls were performed at seven stations in and around the proposed nearshore placement area.

Sediment physical results indicated fairly analogous seafloor composition between stations, with all stations having predominately sandy substrate (97.3% to 98.6% sand) with trace silt and clay (1.4% to 2.5%) and little to no gravel (0.0% to 0.2%). No consistent or significant spatial pattern was observed in sediment chemical results and since these parameters are primarily intended as a baseline for future site monitoring, the chemical results are not relied upon for siting the placement area.

Water physicochemical data from the survey do not indicate large differences inside and outside the placement area. This was predicted considering the relatively small distances between stations, similarities of depth and substrate, and frequent mixing of near-shore continental shelf waters.

Benthic infaunal community composition and community structure did not differ significantly between stations inside and outside the placement area, except for relative abundance, which was statistically significantly higher outside the placement area. In general, the highest abundance values were observed at the deepest stations sampled. No non-native or invasive taxa were identified from benthic infaunal taxa.

Benthic epifaunal biomass, community composition, and community structure did not differ significantly between stations inside and outside the placement area. The trawl station farthest south and most distant from the south jetty had the lowest epifaunal biomass and community index values. This may be due to the distance from the nearest structure (the south jetty), making it somewhat less attractive to epibenthic invertebrates and demersal fishes compared to stations closer to this structure and the Murrells Inlet estuary. No non-native or invasive taxa were identified from benthic epifaunal taxa.

No evidence was found to indicate any hardbottom or other structures within the survey area. This is consistent with previous studies reviewed and summarized by ANAMAR (2020) as well as the results of a multibeam sonar survey conducted in July 2021 by Geodynamics (2021).

Nothing sampled or recorded during this survey would preclude the placement area from being used for dredged sediment disposal. Information collected during this baseline survey, and presented in this report, represent pre-disposal conditions prior to placement of dredged material at the site. The results of this baseline survey will be used, along with future monitoring results, to determine if dredged material placed at the nearshore placement site has the potential to adversely impact benthic infaunal resources, benthic epifaunal resources, sediment quality, and (or) water quality. Information gleaned from this study, and future studies, will be used to guide management decisions relative to future disposal at the site.

See Exhibit ES-1 below for a summary of the above-discussed parametric comparisons inside and outside the placement area.

Exhibit ES-1. Rapid Comparison of Physical, Chemical and Biological Characteristics Inside and Outside the Proposed Nearshore Placement Area

Parameter Results	Inside Placement Area	Outside Placement Area
Sediment grain size (% mean ± SD)	Gravel: 0.05% (± 0.07%) Sand: 98.0% (± 0.39%) Silt & clay: 1.9% (± 0.35%)	Gravel: 0.05% (± 0.07%) Sand: 98.0% (± 0.35%) Silt & clay: 2.0% (± 0.35%)
Sediment % total solids and TOC (mg/kg)	Total solids: 72.7%–73.7% TOC: 2240–4730	Total solids: 72.2%–76.5% TOC: 3690–4690
Sediment metals, pesticides, PAHs, and PCBs	No major differences observed	
Water physicochemical parameters	No major differences observed	
Infaunal relative abundance (individuals/m²) (mean ± SD)	3467.7 (± 2052.9)	5205.8 (±3070.6)
Significantly different?	**Yes** (*t* statistic > 2.008 and *p*-value < 0.05)	
Infaunal community parameters (mean ± SD)	# of taxa: 43.8 (± 12.7) Shannon diversity: 2.59 (± 0.44) Pielou evenness: 0.69 (± 0.09)	# of taxa: 48.6 (± 14.0) Shannon diversity: 2.26 (± 0.30) Pielou evenness: 0.60 (± 0.11)
Significantly different?	**No** (*t* statistic < 2.120–2.179 and *p*-value > 0.05)	
Epifaunal mean biomass (kg/1,000 m²) (mean, range)	1.8 (1.4–2.3)	1.8 (0.1–4.2)
Significantly different?	**No** (*t* statistic < 2.78 and *p*-value > 0.05)	
Epifaunal relative abundance (individuals/m²) (mean, range)	18.0 (11.5–28.1)	25.8 (0.8–80.2)
Epifaunal community parameters (mean ± SD)	Shannon diversity: 0.90 (± 0.065) Pielou evenness: 0.42 (± 0.035) Margalef richness: 1.83 (± 0.45)	Shannon diversity: 0.76 (± 0.28) Pielou evenness: 0.41 (± 0.21) Margalef richness: 1.61 (± 0.39)
Significantly different?	**No** (*t* statistic < 2.78–3.18 and *p*-value > 0.05)	
Non-native species identified in samples	0	0

1 INTRODUCTION

This report describes the field survey methods, analytical analysis, and results for the baseline environmental studies of the proposed nearshore placement area off Murrells Inlet, South Carolina. The purpose of this study is to document baseline conditions within Atlantic Ocean waters in an area proposed for a nearshore dredged material placement area, within approximately 2 nautical miles (nmi) from the jetties at Murrells Inlet. Physical, chemical, and biological parameters at the time of the survey are documented in and around the area proposed for dredged material placement. Information collected during the baseline survey, and presented in this report, represent pre-disposal conditions prior to placement of dredged material at the site.

The results of this baseline survey will be used, along with future monitoring results, to determine if dredged material placed at the nearshore placement site has the potential to adversely impact benthic infaunal resources, benthic epifaunal resources, sediment quality, and (or) water quality. Information gleaned from this study, and future studies, will be used to guide management decisions relative to future disposal at the site.

1.1 Roles and Responsibilities

Regulatory agencies and their responsibilities are summarized in Exhibit 1-1 below. The project management team and their responsibilities are summarized in Exhibit 1-2.

Exhibit 1-1. Primary Regulatory Agencies and Responsibilities

Agency and Contact Information	Area(s) of Responsibility
U.S. Environmental Protection Agency (EPA) Region 4 Technical Manager: Gary Collins Wetlands & Marine Regulatory Section 61 Forsyth Street SW Atlanta, Georgia 30303 Phone: (404) 562-9395 Email: Collins.GaryW@epamail.epa.gov	Review, comment, and approval of the SAP/QAPP. Review survey results and provide guidance on approval of the site for use under MPRSA Section 103(b) guidance.
U.S. Army Corps of Engineers (USACE) Charleston District Technical Point of Contact: Nathaniel Ball USACE, Charleston District 69A Hagood Avenue Charleston, South Carolina 29403 Phone: (843) 329-8047 Email: Nathaniel.I.Ball@usace.army.mil	Review, comment, and approval of the SAP/QAPP. Review survey results and provide guidance on approval of the site for use under MPRSA Section 103(b) guidance. Assist with state agency coordination. Review permit application.

Additional Agency Coordination

Coordination activities with other federal and state agencies is summarized below. Agency engagement and input on the front end of the study was conducted to ensure concerns were raised and addressed early on and were incorporated into the baseline studies as needed.

- National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS): Informal consultation pursuant to Section 7 of the Endangered Species Act for species under their jurisdiction.

- NMFS: Essential fish habitat consultation and conservation recommendations pursuant to Section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA).
- South Carolina Department of Natural Resources (SC DNR): Coordination and recommendations regarding any potential impacts to aquatic resources.
- South Carolina Department of Health and Environmental Control (SC DHEC) and Office of Ocean and Coastal Resource Management (OCRM): Coastal Zone Consistency (CZC) concurrence that the proposed project is consistent with the policies of the South Carolina Coastal Zone Management Act. A Clean Water Act Section 401 water quality certification will also be sought from SC DHEC along with a permit for dredging and (or) dredged material disposal.
- South Carolina State Historic Preservation Office (SHPO): Concurrence that the proposed project is consistent with the National Historic Preservation Act (NHPA).

Exhibit 1-2. Project Management Team and Responsibilities

Company and Contact Information	Area(s) of Responsibility
Georgetown County Project Manager: Art Baker, P.E. 129 Screven Street Georgetown, South Carolina 29442 Phone: 843-545-3255 abaker@gtcounty.org	Oversight and management of project and contractors for Georgetown County
GEL Engineering, LLC Project Manager: Tom Hutto, P.G. PO Box 30712 / 2040 Savage Road Charleston, South Carolina 29417 / 29407 Phone: 843-697-2200 Email: thomas.hutto@gel.com	Overall project management and subcontractor oversight; agency and client coordination; technical review of SAP/QAPP, technical review of sediment fate modeling and multibeam survey reports, field services support; permitting; dredge design, development of a dredged material management plan
ANAMAR Environmental Consulting, Inc Project Manager: Michelle Rau 2106 NW 67th Place, Suite 5 Gainesville, Florida 32653 Phone: 352-318-5773 Email: mrau@anamarinc.com	SAP/QAPP preparation; planning and oversight of site characterization studies; managing subcontractors for laboratory analysis; data quality assurance/quality control (QA/QC); preparation of report deliverables
Water Environment Consultants (WEC) Project Manager: Matt Goodrich, P.E. PO Box 2221 Mount Pleasant, South Carolina 29465 Phone: 843-375-9022 ext. 2 Email: mgoodrich@water-ec.com	Sediment fate modeling and analysis for selection of preferred nearshore placement site, technical review of SAP/QAPP, field services support.

Exhibit 1-3. Subcontractors and Responsibilities

Company and Contact Information	Area(s) of Responsibility
Barry A. Vittor & Associates, Inc. Project Manager: Lauree Stober 8060 Cottage Hill Road Mobile, Alabama 36695 Phone: 251-633-6100 Email: lstober@bvaenviro.com	Identification and enumeration of benthic organisms; calculation of community indices; statistical comparisons
Eurofins TestAmerica Project Manager: Carrie Gamber 301 Alpha Drive Pittsburgh, Pennsylvania 15238 Phone: 412-963-2428 Email: Carrie.Gamber@eurofinset.com	Laboratory sample preparation and PCB congener analysis of sediment; sample holding and archiving
GEL Laboratories, LLC Project Manager: Jake Crook 2040 Savage Road Charleston, South Carolina 29407 Phone: 843-769-7390 Email: jhc@gel.com	Laboratory sample preparation and chemical analysis of sediment; sample holding and archiving
Soil Consultants, Inc. Project Manager: Taylor Johnson PO Drawer 698 | Charleston, SC 29402-0698 Phone: 843-723-4539 Email: tjohnson@soilconsultantsinc.com	Laboratory sample preparation and physical analysis of sediment; sample holding and archiving
GEL Engineering, LLC Boat Captain: Don Lanter 2040 Savage Road Charleston, South Carolina 29407 Phone: 843-906-9814 Email: drl@gel.com	Provide vessel for conducting survey operations including sediment sampling, benthic infaunal sampling, and epifaunal trawl sampling

2 SITE DESCRIPTION AND BACKGROUND

2.1 Project Area

Murrells Inlet is approximately 14 miles southwest of Myrtle Beach (Figure 2-1). The inlet connects a small estuary to Long Bay on the Atlantic Ocean. The inlet is bordered to the north by Garden City Beach and to the south by Huntington Beach State Park. The estuary includes numerous tidal creeks along with a federal navigation channel maintained by USACE (Figure 2-2).

A pair of armor-stone jetties border the inlet at the entrance channel. The north jetty is 3,455 feet long and the south jetty measures 3,319 feet long (Seabergh and Thomas 2002). These jetties were built in 1977 to an elevation of 9 feet mean low water (MLW). An 8-foot-wide fishing walkway was constructed on the crest of the south jetty to an elevation of 10 feet MLW (Seabergh and Thomas 2002). The eastern (seaward) ends of these jetties are 600 feet apart with a 300-foot-wide entrance channel that is maintained at 12 feet MLW. The inner channel is maintained to a depth of 10 feet MLW (Seabergh and Thomas 2002).

Residential and commercial properties abut most of the northern two-thirds of the estuary, whereas the southern third is largely undeveloped and bounded by Huntington Beach State Park and Brookgreen Gardens. The majority of Murrells Inlet is in Georgetown County, with the northern end situated in Horry County. Users of the estuary include commercial entities, the general public, and owners of land abutting the waterways.

The seafloor surrounding Murrells Inlet is composed primarily of sandbars and tidal deltas, often extending 2 or more miles into the Atlantic (Freeman and Walford 1976, SC Ocean Planning Working Group 2012). The sand and silty sand continue offshore for about 20 miles, where the seafloor slopes down to about 60 feet. Most of seafloor off Murrells Inlet and elsewhere along the Grand Strand is devoid of structure (Holshouser 2016). Occasionally, there are scattered rocky outcroppings, ridges, ledges, derelict vessels, and artificial reefs in parts of the surrounding continental shelf (Freeman and Walford 1976). Weinbach and Van Dolah (2001) found that areas they sampled within about 2 miles of Murrells Inlet had grain size major modes (phi) of >2 to 4 (<0.250 to 0.062 mm), indicating fine to very fine sand based on a combination of grab sampling, core and vibracore sampling, and the use of a sub-bottom profiler.

Due in part to the paucity of naturally occurring hardbottom areas along the South Carolina coast (South Carolina Department of Natural Resources [SC DNR] 2015), artificial reefs have been created and are actively used by local recreational fishers. The artificial reefs off South Carolina are relatively small and support only small numbers of fishes capable of being harvested during a given season (SC DNR 2015).

There are four permitted artificial reef areas within 10 nmi of Murrells Inlet. Permitted area 07 (PA-07) is 9.0 nmi northeast of the inlet in 35 feet of water. PA-07 was created in 2016 and consists of 14 groups of concrete junction boxes and concrete culverts over an area 400 yards in diameter (Holshouser 2016). The closest permitted area is PA-09, composed of a cluster of five named artificial reefs in 35 feet of water located 3.2 nmi east of the inlet (SC DNR 2015). This reef complex is likely visited frequently by fishers out of Murrells Inlet as its proximity allows for easy visitation by even small vessels during fair weather. The second-closest permitted area to the inlet is PA-11 in 35 feet of water located 5.5 nmi southeast of the inlet (SC DNR 2015). This area has two named reefs and is composed of a variety of vehicles and concrete pieces. Permitted area PA-10 is composed of three named artificial reefs in 45 feet of water located 9.5 nmi southeast of the inlet (SC DNR 2015).

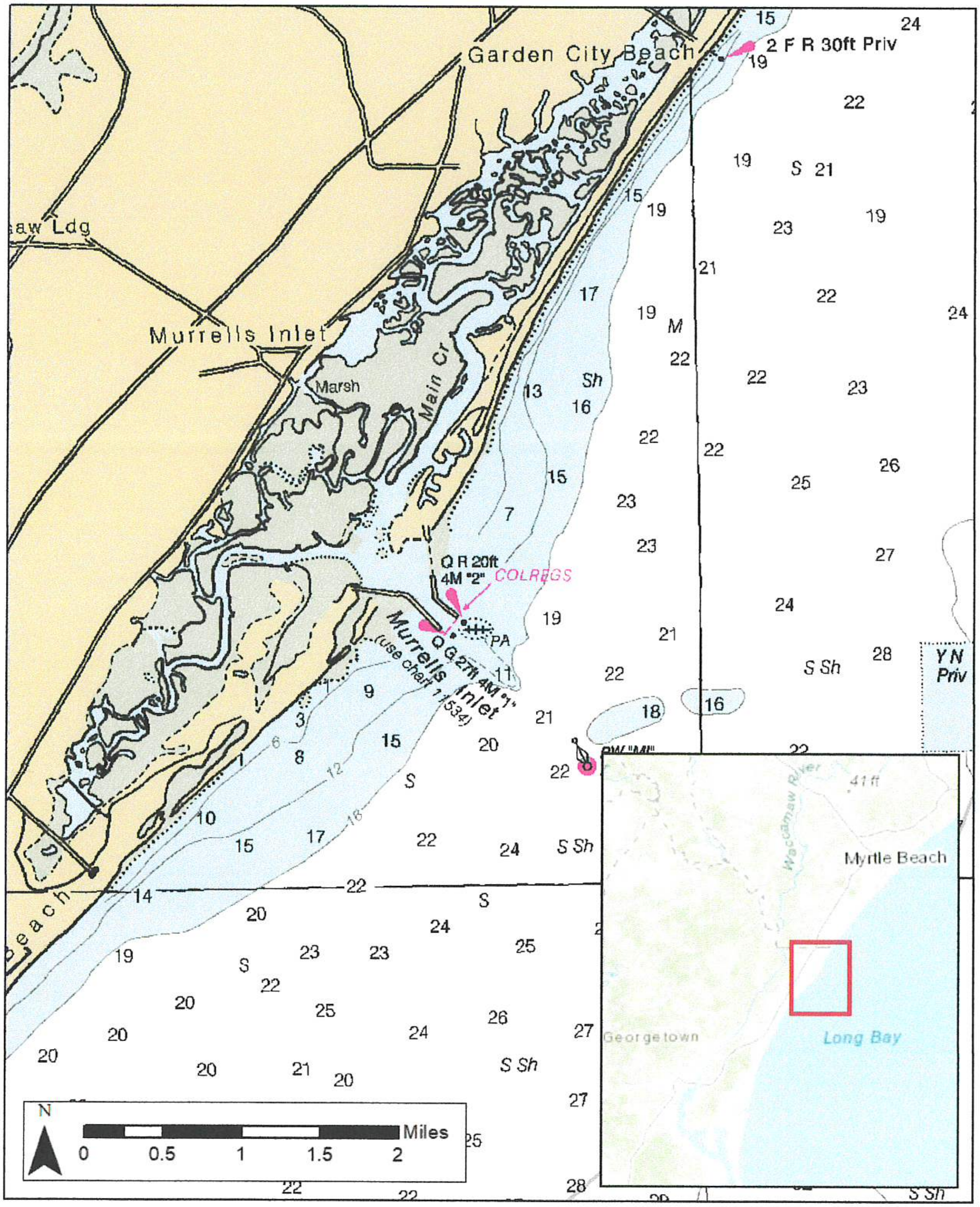


Figure 2-1. Project Location Map

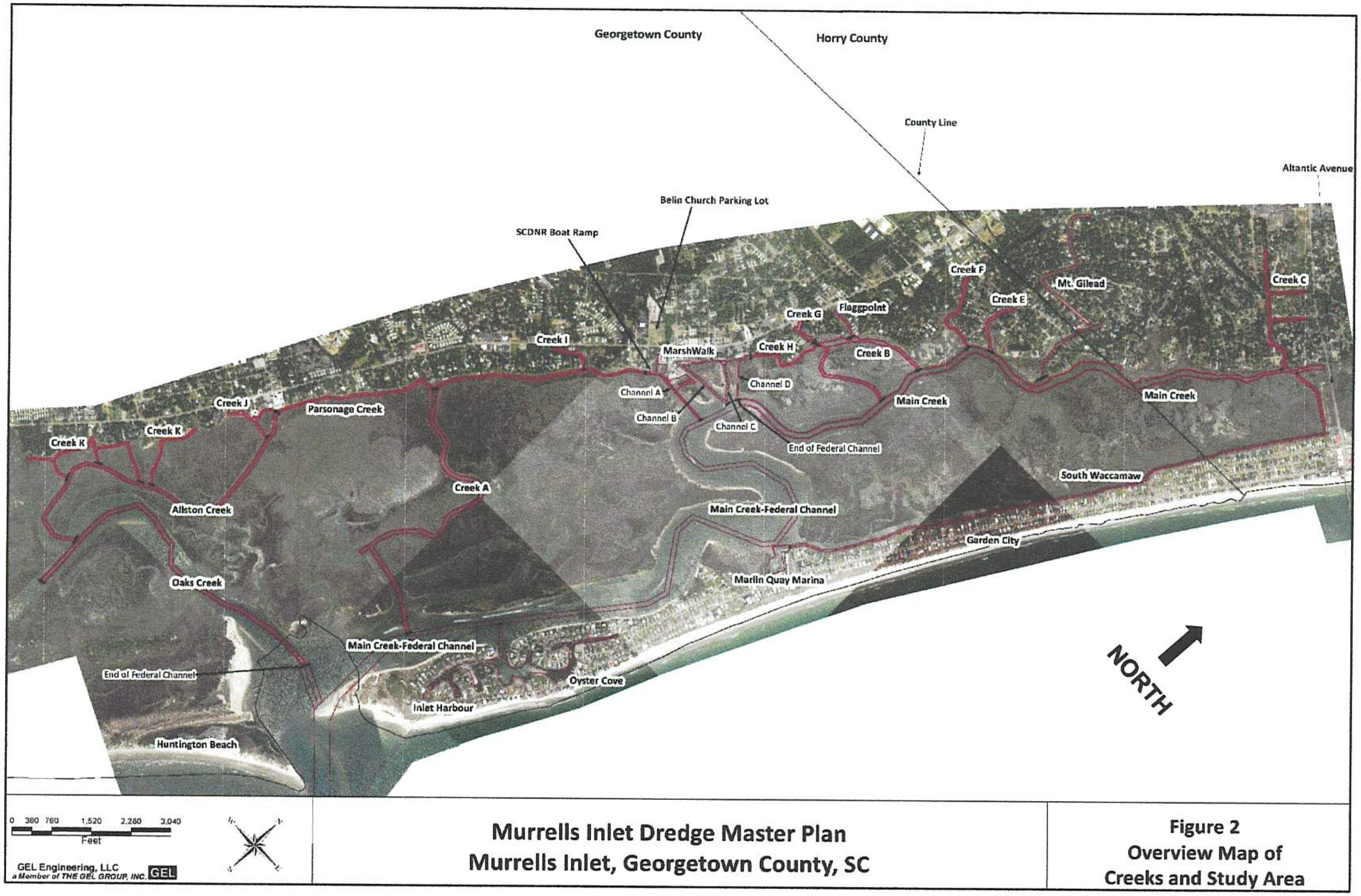


Figure 2-2. **Murrells Inlet Overview of Tidal Creeks, the Federal Channel, and Vessel Amenities**
Source: GEL Engineering, LLC

2.2 Purpose and Need

The importance of navigation in Murrells Inlet has long been recognized. The need for safe navigation is reflected by the federal government which has constructed and continues to maintain a jetty system to ensure safe navigation through the inlet and a federal navigation channel in portions of the estuary. Historically, the major creeks in Murrells Inlet have been navigable at all tides. Some of the natural creeks were deepened, and some man-made creeks were created by excavation of uplands to provide deepwater access to Murrells Inlet. Over time, siltation has reduced depths in portions of many channels such that they are no longer navigable during much of the tide cycle. The proposed maintenance dredging and disposal project is needed to provide the public with safe access to the estuary for recreation and to support existing commercial entities and homeowners that border Murrells Inlet.

Historically, maintenance dredging has been accomplished on an *ad hoc* basis. USACE periodically dredges portions of the federal channel, and the sediment has been used either for beach renourishment or to protect the south jetty. Georgetown County, local marinas, and homeowner associations have also conducted maintenance dredging in areas outside the federal channel. Over time, dredging has become more complex and costly, which has compelled Georgetown County to search for a better method to manage maintenance dredging in the estuary, ideally a method that retains sediment in the marine system.

GEL and ANAMAR (2020) prepared a document that details the purpose and need, dredging history, and placement options that were considered as part of the preliminary research conducted so far. ANAMAR (2020) documented the shipping lanes and navigational restrictions, essential fish habitat, hardbottom, artificial reefs, endangered species, local fisheries, and other considerations as part of a preliminary literature search. Geodynamics (2021) performed a multibeam sonar survey in and around the proposed placement area and described their findings in a report. Water Environment Consultants (WEC 2021) conducted sediment fate modeling to predict the behavior of dredged sediment that may be disposed of at the nearshore placement area.

Based on recent hydrographic surveys and a preliminary dredge design, approximately 590,000 to 730,000 cy of dredged material needs to be removed from the channels within Murrells Inlet to provide sufficient access during all tidal stages to the existing federal navigation channel and the Atlantic Ocean. GEL and Georgetown County conducted an alternatives analysis to identify the best long-term sustainable placement method for sediment dredged from the project area. The analysis considered numerous placement options, including thin-layer placement, side-casting, and upland or landfill placement; however, only ocean placement is feasible given the volume of material to be dredged. No feasible means were identified to dispose even a fraction of the projected dredge volume reflecting that nearshore disposal is the only feasible option to conduct meaningful dredging.

For the purposes of this project, the term nearshore dredged material placement area (or nearshore placement area) is synonymous with the term ocean dredged material disposal site (ODMDS) used in federal regulations that explain the site-selection process. Since the proposed site will be located within the active littoral zone rather than offshore, the term nearshore dredged material placement area provides a better description of the proposed site (GEL and ANAMAR 2020).

2.3 Proposed Action

The action being considered is the siting of a nearshore dredged material placement area off Murrells Inlet in Georgetown County, South Carolina, pursuant to Section 103(b) of the Marine Protection, Sanctuaries, and Research Act (MPRSA). The site would be used periodically to dispose of suitable dredged material from channels within the inlet. Typically, ocean-going scows are used to transport material to an offshore placement site. In this case, use of scows is not feasible given the shallow depths of the creeks. Therefore, the proposed dredging project will use hydraulic dredges to pump the material to the placement area via pipeline.

3 BASELINE OBJECTIVES AND STUDY DESIGN

3.1 Study Objectives

This baseline site characterization study of the proposed nearshore placement site and adjacent area was designed to assess the existing physical, chemical, and biological characteristics of the area. Baseline data from this survey will be used to assess the appropriateness of this location for disposal of dredged material and, if the area is approved by USACE and EPA, would then be compared with post-disposal monitoring data to detect any unacceptable impacts to the marine environment that might be attributable to dredged material placement activities. The study objectives are to:

1. Collect and characterize *in situ* water physicochemical data including depth, temperature, salinity, and dissolved oxygen at stations within and outside the site
2. Provide a baseline physical characterization of the sediments within and outside the site
3. Provide a baseline chemical characterization of sediments within and outside the site
4. Characterize the benthic infaunal community within and outside the site
5. Characterize the demersal fish and benthic invertebrate community (species composition and community indices [taxonomic richness, evenness, diversity]) within and outside the site
6. Provide a basis of comparison for future monitoring efforts, as required by permitting agencies

3.2 Proposed Nearshore Placement Area Location

The coordinates of the proposed nearshore placement area boundaries are summarized in Exhibit 3-1. The placement area, and expanded survey area, are shown in Figure 3-1 in relation to the general area in need of maintenance dredging within Murrells Inlet.

An expanded survey area (Exhibit 3-2, outlined in a blue border in Figures 3-1 through 3-3) was included to provide flexibility in the final location and configuration of the placement area. This expanded area was chosen based on feedback from resource agencies and other stakeholders during initial coordination efforts and from feedback from these agencies during the review of sediment fate modeling efforts.

Exhibit 3-1. Coordinates of the Proposed Nearshore Placement Area

Site	Site Corner	Easting, Northing (U.S. Survey feet)		NAD 83 (decimal degrees)	
		x	y	Lat (°N)	Long (°W)
Nearshore Placement Area Boundaries	NW	2599769	619410	33.520096	-79.031677
	NE	2602104	617527	33.514798	-79.024134
	SE	2598965	613635	33.504267	-79.034674
	SW	2596630	615518	33.509564	-79.042218

Dimensions of the nearshore placement area:

Length: 5,000 feet (0.95 miles) (oriented parallel to shore)

Width: 3,000 feet (0.57 miles) (oriented perpendicular to shore)

Area: 0.54 square miles (139.4 hectares)

Exhibit 3-2. Coordinates of the Expanded Survey Area

Site	Survey Area Corner	Easting, Northing (U.S. Survey feet)		NAD 83 (decimal degrees)	
		x	y	Lat (°N)	Long (°W)
Expanded Survey Area Boundaries	NW	2599769	619410	33.520096	-79.031677
	NE	2603259	616575	33.512122	-79.020403
	SE	2599192	611426	33.498183	-79.034069
	SW	2595646	614391	33.506517	-79.045515

Dimensions of the expanded survey area:

Length: 6,500 feet (1.23 miles) (oriented parallel to shore)

Width: 4,500 feet (0.85 miles) (oriented perpendicular to shore)

Area: 1.07 square miles (276.7 hectares)

3.3 Study Design

The sampling stations within and outside the proposed nearshore placement area are located to ensure consistent and adequate spatial coverage of the project area. The sampling methods and total number of sampling stations were determined, in part, by the relative size of the site and sample density sufficient to provide meaningful information. The sample design, location, and density of sampling stations were coordinated with EPA, USACE, and the Georgetown County team. Sampling locations are depicted in Figures 3-2 and 3-3. Station location coordinates and station IDs are in Exhibits 3-3 and 3-4 for sediment and infaunal grab sampling, and trawl sampling, respectively.

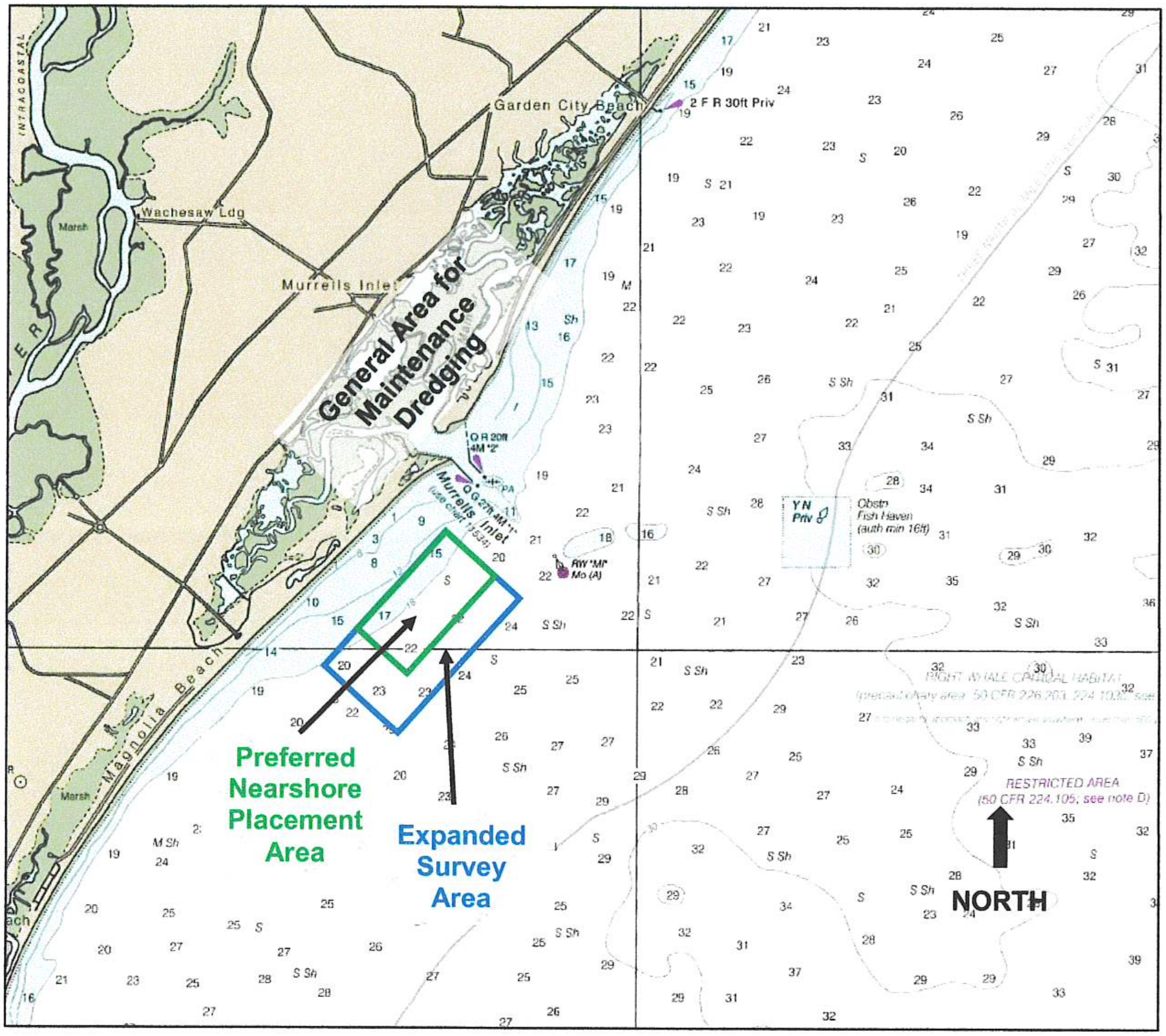


Figure 3-1. The Preferred Nearshore Placement Area and Expanded Survey Area in Relation to the Maintenance Dredging Area

Source: Nautical chart modified from National Oceanic and Atmospheric Administration (NOAA) Chart 11535, 13th edition, 02/12, last corrected 12/30/19

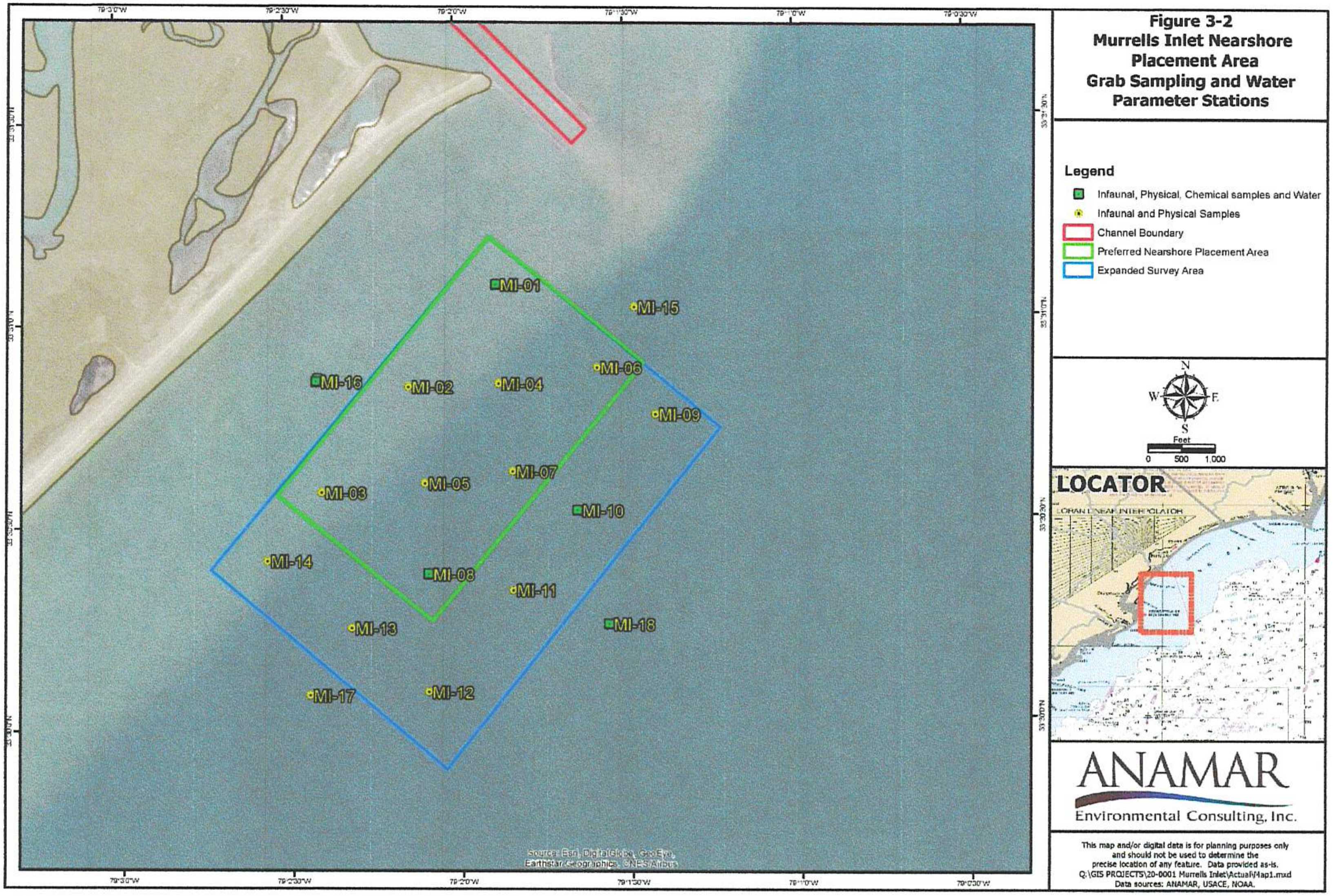


Figure 3-2. Stations Sampled for Infaunal, Physical, and Chemical Analysis and Water Physicochemical Parameters, Murrells Inlet Nearshore Placement Area

Note: The blue border is an expanded survey area added to provide flexibility in the final location and configuration of the placement area.

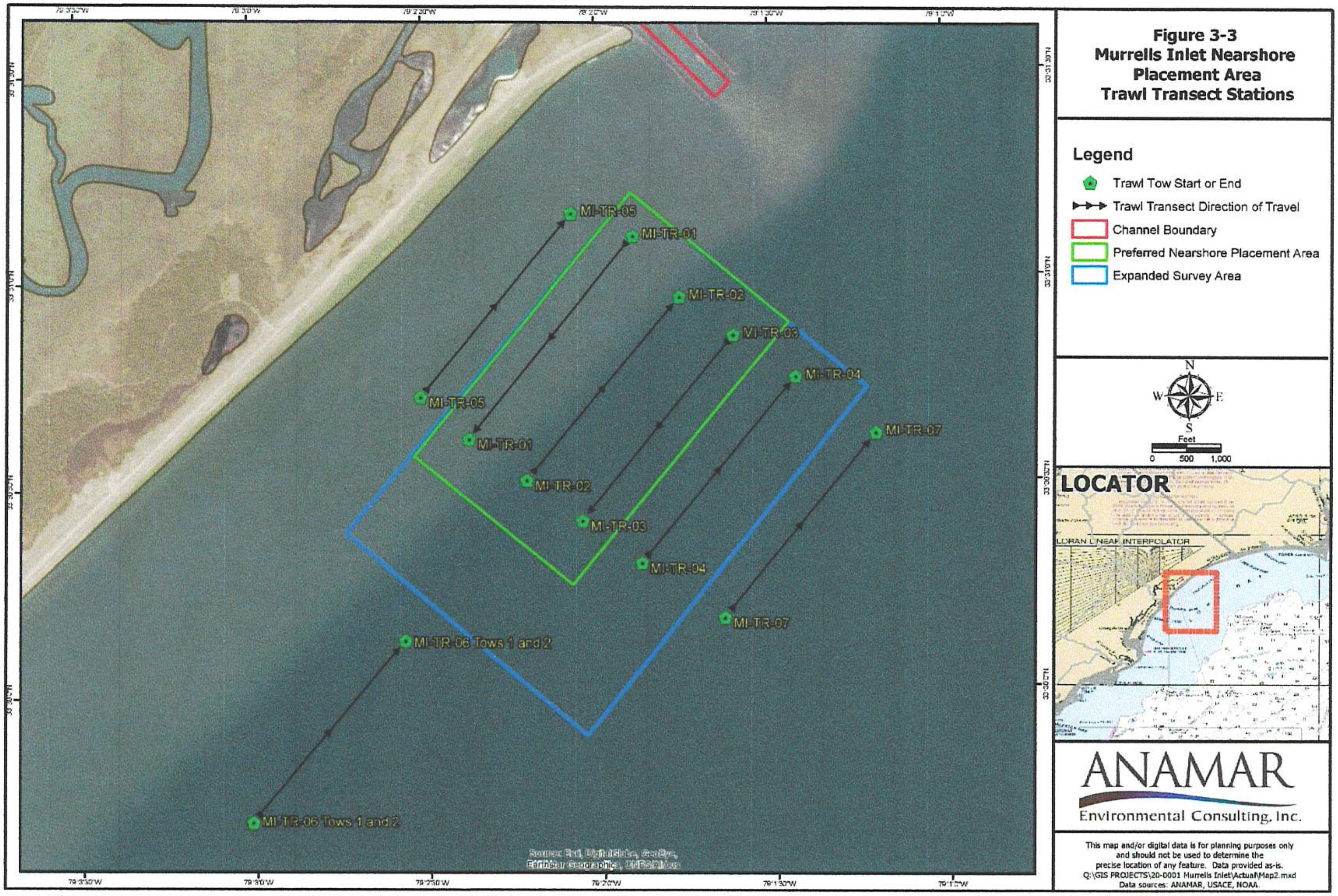


Figure 3-3. Trawl Stations for Epifaunal Sampling, Murrells Inlet Nearshore Placement Area

Note: The blue border is an expanded survey area added to provide flexibility in the final location and configuration of the placement area.

Exhibit 3-3. Station IDs and Coordinates for Collection of Sediment Physical, Chemical, and Benthic Infaunal Samples and Water Physicochemical Parameters

Station ID	Location Relative to Proposed Nearshore Placement Area	NAD 83 (Latitude)	NAD 83 (Longitude)	Physical Analysis	Benthic Infaunal Analysis *	Sediment Chemical Analysis	Water Physicochemical Readings
MI-01	Inside	33.518126	-79.031385	X	X	X	X
MI-02	Inside	33.513974	-79.035735	X	X		
MI-03	Inside	33.509663	-79.040058	X	X		
MI-04	Inside	33.514042	-79.031298	X	X		
MI-05	Inside	33.509987	-79.034973	X	X		
MI-06	Inside	33.514671	-79.026445	X	X		
MI-07	Inside	33.510427	-79.030661	X	X		
MI-08	Inside	33.506233	-79.034858	X	X	X	X
MI-09	East of placement area	33.512704	-79.023612	X	X		
MI-10	East of placement area	33.508773	-79.027495	X	X	X	X
MI-11	East of placement area	33.505520	-79.030709	X	X		
MI-12	South of placement area	33.501363	-79.034922	X	X		
MI-13	South of placement area	33.504051	-79.038665	X	X		
MI-14	South of placement area	33.506867	-79.042764	X	X		
MI-15	North of placement area	33.517122	-79.024591	X	X		
MI-16	West of placement area	33.514338	-79.040185	X	X	X	X
MI-17	South of placement area	33.501302	-79.040759	X	X		
MI-18	East of placement area	33.504051	-79.026022	X	X	X	X
			Total Number of Samples	**18**	**18 x 3 = 54 samples**	**5**	**5**

* Three pseudo-replicate samples were collected from each station for benthic infaunal analysis (54 total samples).

Exhibit 3-4. Trawl Station IDs and Start/End Coordinates

Station ID	Location in Relative to the Proposed Nearshore Placement Area	Start Transect NAD 83 (Latitude)	Start Transect NAD 83 (Longitude)	End Transect NAD 83 (Latitude)	End Transect NAD 83 (Longitude)
MI-TR-01	Inside placement area	33.518375	33.510235	-79.039584	33.510235
MI-TR-02	Inside placement area	33.508536	-79.036849	33.515881	-79.029407
MI-TR-03	Inside placement area	33.514721	-79.026439	33.506867	-79.034188
MI-TR-04	East of placement area	33.505128	-79.031354	33.512584	-79.023849
MI-TR-05	West of placement area	33.511951	-79.041880	33.519330	-79.034543
MI-TR-06 (tow #1)	South of placement area	33.494852	-79.050210	33.502163	-79.042769
MI-TR-06 (tow #2)	South of placement area	33.494876	-79.050205	33.502165	-79.042768
MI-TR-07	East of placement area	33.510254	-79.020028	33.502874	-79.027403

Notes: All trawl tows were in a southwestern direction, with the exceptions of MI-TR-02 and MI-TR-04, which were in a northeastern direction.

4 FIELD METHODS AND MATERIALS

Sampling activities were conducted according to the SAP/QAPP (Appendix A).

Field sampling took place April 12 through 16, 2022. Field personnel consisted of scientists from ANAMAR and GEL Engineering. The survey vessel, a 25-foot C-Hawk, departed from a dock at Crazy Sister Marina at Murrells Inlet during each survey day. Exhibit 4-1 is a summary of the sampling activities. For further details, see the DQCRs provided in Appendix B.

Exhibit 4-1. Sampling Activities

Date	Activity
11-Apr-2022	• Field sampling team arrives at Murrells Inlet, SC
12-Apr-2022	• Load vessel, prepare and organize equipment and supplies, conduct health and safety meeting and risk assessment • Collect sediment and infaunal samples from stations MI-01, 02, 08, and 16 • Vessel returns to marina dock due to adverse afternoon weather
13-Apr-2022	• Collect sediment and infaunal samples from stations MI-03, 05, 06, 09 through 14, 18, and most of the samples from MI-07 • Repair ruptured fuel hose bulb on vessel
14-Apr-2022	• Collect sediment and infaunal samples from stations MI-04 and 15 and complete remaining infaunal sampling at station MI-07 • ANAMAR ships sediment samples MI-01, 08, 10, 16, and 18 to Eurofins TestAmerica for PCB congener analysis • ANAMAR ships benthic infaunal samples MI-01 (A, B, C) through MI-18 (A, B, C) to Barry A. Vittor & Associates, Inc. for identification and community assessment • Vessel returns to marina, switch out grab sampling equipment for trawl sampling equipment, suspension of further field operations due to unsuitable weather
15-Apr-2022	• Field operations suspended for day due to unsuitable weather • ANAMAR delivers sediment samples MI-01 through MI-18 to Soil Consultants, Inc. for physical analysis • ANAMAR delivers sediment samples MI-01, 08, 10, 16, and 18 to GEL Laboratories for chemical analysis
16-Apr-2022	• Collect trawl samples from stations MI-TR-01 through MI-TR-07 • Field sampling team leaves Murrells Inlet, SC
17-Apr-2022	• ANAMAR senior biologist identifies, measures, and enumerates remaining trawled epifaunal samples in Gainesville, FL

4.1 Sample Position Accuracy

All aspects of navigation and positioning control were handled by the boat captain, with consultation from the ANAMAR field team leader as needed. Using the vessel's GPS, the captain navigated as closely as possible to the target sampling location (typically within 50 feet of the target), and the location was confirmed with the second GPS unit operated by ANAMAR staff. All samples were collected as close as possible to the targeted sampling location.

4.2 Field Parameters

Site conditions such as prevailing weather, wind direction, and tidal cycle were documented at each sampling station and during trawl tows. Water depth, date and time, coordinates, current conditions, sample descriptions, and numbers of containers are recorded on project-specific field logs (provided in Appendix B).

4.3 Sampling Methods

4.3.1 Water Physicochemical Measurements

Water physicochemical parameters were measured and recorded at five stations (two stations inside the placement area and three stations outside of this area) as shown in Figure 3-1 and indicated in Table 3. A probe was lowered into the water column to collect conductivity, pH, temperature, salinity, dissolved oxygen, and water depth data at approximately 3 feet (1 meter) above the bottom. These data were recorded on field logs (provided in Appendix B).

4.3.2 Grab Sampling for Sediment and Benthic Infaunal Sampling

Sediment samples for chemical, physical, or benthic infaunal analysis were collected using a Ponar grab sampler. A Ponar grab sampler has a sampling area of 523 square cm, a maximum sample volume of 8.2 liters, and a maximum sampling depth of 10 cm.

Upon retrieval, the sample was inspected to ascertain compliance with the following sample acceptance criteria:

- Overlying water is present (minimal water leaking from the bottom of the sampler)
- Adequate penetration depth is achieved (generally ≥5 cm unless three sampling attempts at the same station yielded consistently shallow depths)
- Sampler is not overfilled
- Sediment surface is relatively undisturbed

Figure 4-1 presents examples of acceptable and unacceptable grab samples. Each acceptable sample was photographed and processed for sediment physical analysis, chemical analysis, or benthic infaunal analysis. Photos of acceptable sediment and infaunal samples are in Appendix C.

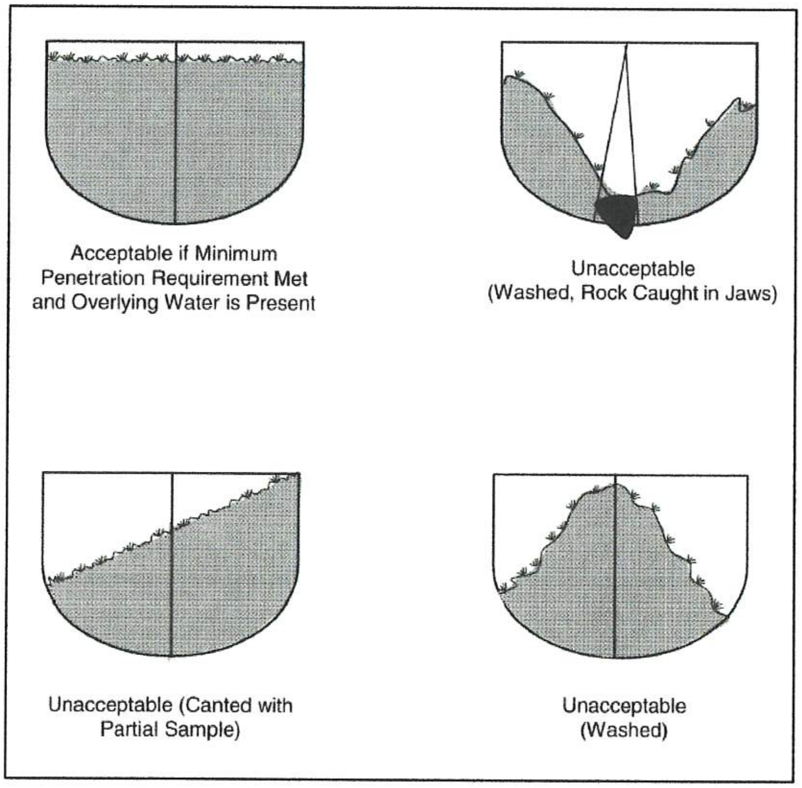


Figure 4-1. Examples of Acceptable and Unacceptable Grab Samples

Source: modified from Figure 3-4 of EPA (2001)

4.3.3 Sediment Physical and Chemical Analysis

The Ponar grab was operated with an electric winch and line mounted on a davit from the port side of the survey vessel. Once the sampler was on-deck and determined to meet the acceptance criteria from Subsection 4.3.2, the sample was photographed, containerized, labeled, and stored on ice (or at ambient temperature in the case of samples for physical analysis).

Sediment grab samples for physical analysis were collected at 18 stations:

- Inside placement area: 8 stations
- North of placement area: 1 station
- South of placement area: 4 stations
- West of placement area: 1 station
- East of placement area: 4 stations

Sediment grab samples for chemical analysis were collected at five stations. Two grab samples were collected at station locations within the proposed site to characterize baseline sediment chemistry inside the boundaries of the proposed site. Three grab samples were collected at stations outside the site (two east and one west of the proposed site) to characterize baseline sediment chemistry outside the boundaries of the proposed site. These locations will also serve as future reference stations for post-placement monitoring surveys.

4.3.4 Benthic Infaunal Sampling

Three pseudo-replicates were collected by Ponar grab at each of the 18 stations within and outside the proposed nearshore placement area. Photos of infaunal samples are included in Appendix C. Benthic grab sample station locations within the proposed site were selected to be evenly distributed in a grid pattern across the placement area. Stations outside the placement area were selected to characterize benthic communities surrounding the proposed site, to provide future reference stations for post-disposal monitoring surveys, and to provide an expanded survey area in the event the site boundaries need to be shifted.

For the purposes of this survey report, the term 'infauna' refers to invertebrates greater than 0.5 mm in length that live in sediment. Major taxonomic groups that fit the infauna description include: polychaete worms (e.g., lugworms, sandworms), mollusks (e.g., scallops, clams, oysters, mussels, snails), crustaceans (crabs, shrimps, amphipods), echinoderms (sea stars, sea cucumbers, sea urchins), and sipunculid worms (also known as peanut worms).

Three pseudo-replicate samples were collected at each station for benthic infaunal analysis:

- Inside placement area: 8 stations x 3 pseudo-replicates = 24 samples
- North of placement area: 1 station x 3 pseudo-replicates = 3 samples
- South of placement area: 4 stations x 3 pseudo-replicates = 12 samples
- West of placement area: 1 station x 3 pseudo-replicates = 3 samples
- East of placement area: 4 stations x 3 pseudo-replicates = 12 samples

Each sediment sample meeting the acceptance criteria in Subsection 4.3.2 was decanted from the grab sampler into a stainless steel bin and carefully washed into a standard US #35 mesh size (0.5 mm mesh size) sieve bucket using a deck hose pumping seawater. The samples were wet-sieved by gently agitating the sediment and sieve within a 30-gallon plastic bin filled with seawater on the deck of the vessel. Sieving was completed when only infauna and other large particles remained in the sieve. The retained organisms and other material were then photographed and the transferred to 7-inch by 12.5-inch polyester bags (Hubco Inc., Hutchinson, Kansas). A waterproof label was added before securing the bags closed with a drawstring. The bags were then submerged in 10% buffered formalin inside 5-gallon buckets.

The buckets of infaunal samples were shipped via courier to Barry A. Vittor & Associates, Inc. for sorting and analysis following completion of the sampling event. The percentage of formalin was reduced to 5% prior to shipping to meet current shipping regulations.

4.3.5 Epifaunal (Trawl) Sampling

Invertebrates and fishes were collected with a 4.9-m-wide otter trawl with 30 mm stretch mesh at the front of the net and a net liner of 4-mm knotless mesh. Spatial coordinates were recorded at the beginning and end of each tow, along with the direction of travel, water depth, tide sequence, and weather parameters. Vessel position, as well as time, depth, and vessel speed, were tracked with navigation software throughout each trawled station.

Each successful trawl tow was approximately 15 minutes in duration and conducted at speeds ranging from 2.5 to 3.2 knots (2.9 to 3.7 miles/hour). Sampled station lengths ranged from 3,488 to 3,804 feet (1,063 to 1,160 m) per tow. The direction of travel was southwest for stations MI-TR-01 and 03 and northeast for stations MI-TR-02, 04, 05, 06 (two tows), and 07. All transects followed the bottom contours and were roughly parallel to shore. Approximately 120 feet of scope was used which provided satisfactory performance of the trawl (based on wear on skid plates on the otter doors and catches of epibenthic fauna) and maintained effective spread, diving, and operability of the net. One trawl tow was conducted at each of the stations, except for station MI-TR-06, where two tows were conducted due to a relatively low number of organisms captured during the first attempt (the second attempt had similar results). The trawl stations are mapped in Figure 3-2 along with the proposed boundaries of the nearshore placement area and nearby Huntington Beach State Park. Photos of trawl catches are included in Appendix C. Epifaunal field logs are included in Appendix B.

Trawl samples were collected from the following stations:

- Inside placement area: 3 stations
- West of placement area: 1 station
- East of placement area: 2 stations
- South of placement area: 1 station (this station was sampled twice)

Note that the proximity of Murrells Inlet precludes a trawl station north of the placement area.

All aspects of trawl sampling were conducted in accordance with Scientific Trawl Permit #SC122-0381 obtained March 31, 2022, from the South Carolina Department of Natural Resources, Office of Fisheries Management.

4.3.6 Decontamination

All equipment contacting sediment or water samples was cleaned and decontaminated as described below. Work surfaces on the sampling vessel were cleaned before sampling began on a given day and between sampling stations. Decontamination of all sample-handling equipment occurred before initiation of sampling and between sampling stations to prevent any contamination of samples. The decontamination procedures consisted of the following:

- Wash and scrub to remove gross contamination
- Wash and scrub with Liquinox®
- Rinse with tap or site water (depending on availability)
- Rinse with deionized water
- 2 x rinse with pesticide-grade isopropanol
- 2 x rinse with deionized water
- Air dry

5 ANALYTICAL METHODS AND SAMPLE ANALYSIS

5.1 Sediment Physical and Chemical Analysis

Exhibits 5-1 and 5-2 show the physical and chemical parameters analyzed in the sediment samples. These tables also include the preparation and analytical methodology, target detection limits (TDLs) from the SERIM (EPA and USACE 2008), and the laboratory reporting limits (LRLs). The LRLs can vary due to total solids content. Additionally, matrix interferences can cause the LRL to be elevated.

Analytical results for sediment samples are compared to published sediment screening values as appropriate and in conformance with the Green Book and the SERIM. These levels are the threshold effects level (TEL) and the effects range low (ERL). The TEL represents the concentration below which adverse effects are expected to occur only rarely. The ERL is the value at which toxicity may begin to be observed in sensitive species (Buchman 2008). These comparisons are for reference use only and are not intended for regulatory decision-making.

Total high molecular weight (HMW) PAHs and total low molecular weight (LMW) PAHs are defined by the National Oceanic and Atmospheric Administration (NOAA) (1989). The calculation of total NOAA PCBs also follows NOAA (1989) along with Exhibit 5-6 of the SERIM.

Exhibit 5-1. Sediment Physical Analysis Methods and Quantitation Limits

Parameter	Test Method	Target Measurement/ Quantitation Limit
Grain Size Distribution	ASTM-D422	0.1%
Total Solids/Water Content	ASTM-D2216-80, Plumb 1998	1.0% solids

Exhibit 5-2. Sediment Chemical Analytes, Methods, TDLs, and LRLs

Analyte	Preparation Method	Recommended Test Method	Target Detection Limit * (dry weight)	Laboratory Reporting Limit (dry weight)
METALS				
Antimony	3050B	6010b/200.8	NA	2 mg/kg
Arsenic	3050B	6010b/200.8	1.0 mg/kg	1 mg/kg
Beryllium	3050B	6010b/200.8	NA	0.5 mg/kg
Cadmium	3050B	6010b/200.8	0.10 mg/kg	0.2 mg/kg (Lab MDL = 0.02 mg/kg)
Chromium	3050B	6010b/200.8	1.0 mg/kg	1 mg/kg
Copper	3050B	6010b/200.8	1.0 mg/kg	0.4 mg/kg
Lead	3050B	6010b/200.8	0.5 mg/kg	0.4 mg/kg
Mercury	7471B	7471B	0.05 mg/kg	0.024 mg/kg
Nickel	3050B	6010b/200.8	1.0 mg/kg	0.5 mg/kg
Selenium	3050B	6010b/200.8	1.0 mg/kg	1 mg/kg
Silver	3050B	6010b/200.8	0.2 mg/kg	0.5 mg/kg (Lab MDL = 0.1 mg/kg)
Thallium	3050B	6010b/200.8	NA	2 mg/kg
Zinc	3050B	6010b/200.8	1.0 mg/kg	2 mg/kg (Lab MDL = 0.4 mg/kg)
PESTICIDES				
Aldrin	3541	8081B-LL	10 µg/kg	0.668 µg/kg

Analyte	Preparation Method	Recommended Test Method	Target Detection Limit * (dry weight)	Laboratory Reporting Limit (dry weight)
Chlordane & derivatives	3541	8081B-LL		
Technical Chlordane	3541	8081B-LL	10 µg/kg	8.35 µg/kg
α (cis)–Chlordane	3541	8081B-LL	10 µg/kg	0.668 µg/kg
γ (trans)–Chlordane	3541	8081B-LL	10 µg/kg	0.668 µg/kg
Oxychlordane	3541	8081B-LL	10 µg/kg	0.668 µg/kg
Cis-Nonachlor	3541	8081B-LL	10 µg/kg	0.668 µg/kg
Trans-Nonachlor	3541	8081B-LL	10 µg/kg	0.668 µg/kg
DDT & derivatives	3541	8081B-LL		
p,p' (4,4')-DDD	3541	8081B-LL	10 µg/kg	1.336 µg/kg
p,p' (4,4')-DDE	3541	8081B-LL	10 µg/kg	1.336 µg/kg
p,p' (4,4')-DDT	3541	8081B-LL	10 µg/kg	1.336 µg/kg
Dieldrin	3541	8081B-LL	10 µg/kg	1.336 µg/kg
Endosulfan & derivatives	3541	8081B-LL		
Endosulfan I	3541	8081B-LL	10 µg/kg	0.668 µg/kg
Endosulfan II	3541	8081B-LL	10 µg/kg	1.336 µg/kg
Endrin & derivatives	3541	8081B-LL		
Endrin	3541	8081B-LL	10 µg/kg	1.336 µg/kg
Endrin aldehyde	3541	8081B-LL	10 µg/kg	1.336 µg/kg
Endrin ketone	3541	8081B-LL	10 µg/kg	1.336 µg/kg
Heptachlor and derivatives	3541	8081B-LL		
Heptachlor	3541	8081B-LL	10 µg/kg	0.668 µg/kg
Heptachlor epoxide	3541	8081B-LL	10 µg/kg	0.668 µg/kg
Hexachlorocyclohexane (BHC)	3541	8081B-LL		
α-BHC	3541	8081B-LL	10 µg/kg	0.668 µg/kg
β-BHC	3541	8081B-LL	10 µg/kg	0.668 µg/kg
δ-BHC	3541	8081B-LL	10 µg/kg	0.668 µg/kg
γ-BHC (Lindane)	3541	8081B-LL	10 µg/kg	0.668 µg/kg
Methoxychlor	3541	8081B-LL	10 µg/kg	6.68 µg/kg
Mirex©	3541	8081B-LL	10 µg/kg	0.668 µg/kg
Toxaphene	3541	8081B-LL	50 µg/kg	16.7 µg/kg
PCB CONGENERS				
PCB-8	3541	8082A	1 µg/kg	0.5 µg/kg
PCB-18	3541	8082A	1 µg/kg	0.5 µg/kg
PCB-28	3541	8082A	1 µg/kg	0.5 µg/kg
PCB-44	3541	8082A	1 µg/kg	0.5 µg/kg
PCB-49	3541	8082A	1 µg/kg	0.5 µg/kg
PCB-52	3541	8082A	1 µg/kg	0.5 µg/kg
PCB-66	3541	8082A	1 µg/kg	1 µg/kg
PCB-77	3541	8082A	1 µg/kg	0.5 µg/kg
PCB-87	3541	8082A	1 µg/kg	0.5 µg/kg
PCB-101	3541	8082A	1 µg/kg	0.5 µg/kg
PCB-105	3541	8082A	1 µg/kg	0.5 µg/kg
PCB-118	3541	8082A	1 µg/kg	0.5 µg/kg

Analyte	Preparation Method	Recommended Test Method	Target Detection Limit * (dry weight)	Laboratory Reporting Limit (dry weight)
PCB-126	3541	8082A	1 µg/kg	0.5 µg/kg
PCB-128	3541	8082A	1 µg/kg	0.5 µg/kg
PCB-138	3541	8082A	1 µg/kg	0.5 µg/kg
PCB-153	3541	8082A	1 µg/kg	0.5 µg/kg
PCB-156	3541	8082A	1 µg/kg	1 µg/kg
PCB-169	3541	8082A	1 µg/kg	0.5 µg/kg
PCB-170	3541	8082A	1 µg/kg	0.5 µg/kg
PCB-180	3541	8082A	1 µg/kg	0.5 µg/kg
PCB-183	3541	8082A	1 µg/kg	0.5 µg/kg
PCB-184	3541	8082A	1 µg/kg	0.5 µg/kg
PCB-187	3541	8082A	1 µg/kg	0.5 µg/kg
PCB-195	3541	8082A	1 µg/kg	0.5 µg/kg
PCB-206	3541	8082A	1 µg/kg	0.5 µg/kg
PCB-209	3541	8082A	1 µg/kg	0.5 µg/kg
POLYNUCLEAR AROMATIC HYDROCARBONS				
1-Methylnaphthalene	3541	8270D SIM	20 µg/kg	3.33 µg/kg
2-Methylnaphthalene	3541	8270D SIM	20 µg/kg	3.33 µg/kg
Acenaphthene	3541	8270D SIM	20 µg/kg	3.33 µg/kg
Acenaphthylene	3541	8270D SIM	20 µg/kg	3.33 µg/kg
Anthracene	3541	8270D SIM	20 µg/kg	3.33 µg/kg
Benz(a)anthracene	3541	8270D SIM	20 µg/kg	3.33 µg/kg
Benzo(a)pyrene	3541	8270D SIM	20 µg/kg	3.33 µg/kg
Benzo(b)fluoranthene	3541	8270D SIM	20 µg/kg	3.33 µg/kg
Benzo(g,h,i)perylene	3541	8270D SIM	20 µg/kg	3.33 µg/kg
Benzo(k)fluoranthene	3541	8270D SIM	20 µg/kg	3.33 µg/kg
Chrysene	3541	8270D SIM	20 µg/kg	3.33 µg/kg
Dibenz(a,h)anthracene	3541	8270D SIM	20 µg/kg	3.33 µg/kg
Fluoranthene	3541	8270D SIM	20 µg/kg	3.33 µg/kg
Fluorene	3541	8270D SIM	20 µg/kg	3.33 µg/kg
Indeno(1,2,3-cd)pyrene	3541	8270D SIM	20 µg/kg	3.33 µg/kg
Naphthalene	3541	8270D SIM	20 µg/kg	3.33 µg/kg
Phenanthrene	3541	8270D SIM	20 µg/kg	3.33 µg/kg
Pyrene	3541	8270D SIM	20 µg/kg	3.33 µg/kg
MISCELLANEOUS ANALYTES				
Total Organic Carbon	Method	ASTM D4129-05	0.1%	400 mg/kg (0.04 %)
Ammonia	Method	350.1mod	0.5 mg/kg	1.8 mg/kg ** (Lab MDL = 0.9 mg/kg)
Total Petroleum Hydrocarbons	Method	EPA 1664/9071A	100 mg/kg	100 mg/kg

* Source: Tables 5-1, 5-3, 5-5, and 5-7 of the SERIM (EPA and USACE 2008)

** The Laboratory Reporting Limit is higher than the target detection limit.

5.2 Benthic Infaunal Analysis

Biological and community characterization of benthic infauna was performed by Barry A. Vittor & Associates, Inc. The tasks included sorting, identification, and enumeration of macroinvertebrate organisms collected at each station. The community parameters listed below were statistically compared for the group of eight stations inside the proposed placement area and the 10 stations outside of this area.

Barry A. Vittor & Associates calculated the following numerical indices for each station:

- Infaunal abundance (total number of individuals)
- Infaunal relative abundance (total number of individuals per square meter)
- Taxonomic richness (total number of taxa represented per station)
- Taxonomic diversity (distribution of individuals across taxa)
- Taxonomic evenness

The Barry A. Vittor lab also included a complete list of macroinvertebrate taxa collected and identified from the survey. ANAMAR summarized and interpreted the benthic infaunal community data in this report.

5.3 Trawled Epifaunal Analysis

Characterization of trawl-caught invertebrates and fishes was performed by ANAMAR. Upon completion of each tow, specimens were removed from the trawl net and bag, taking care not to overlook any specimens still contained in the net (to avoid cross-contamination between samples). Each trawl sample was then weighed (wet weight) using a 19-liter plastic bucket with drain holes and either a 5-kg or 20-kg hanging Macro Line scale having an accuracy within 0.3% of maximum weight. All invertebrate and fish species were enumerated and taxonomically identified to the lowest practical taxonomic level (typically to species level). The first 10 individuals of each fish species within each trawl sample were measured as standard length to the nearest mm. Penaeid shrimp were measured as post-orbital carapace length to the nearest mm. All data were recorded on project-specific epifaunal field logs (Appendix B).

ANAMAR performed the following analyses and data for each trawl station and groups of stations (inside versus outside the placement area):

- Estimation of area sampled
- A map showing the trawl sampling locations and directions of travel
- Wet weight biomass
- Relative abundance
- General taxonomic composition of trawl samples
- Taxonomic richness
- Taxonomic evenness
- Taxonomic diversity
- Community composition
- Notes on non-native introduced species, if found
- A brief characterization of the benthic epifaunal community based on trawl samples

6 RESULTS AND DISCUSSION

Field sampling took place April 12 through 16, 2022, by ANAMAR and GEL Engineering. The weather was satisfactory for sampling except for the afternoons of April 12 and 13, the late morning and afternoon of April 14, and all day on April 15 due to rough sea conditions.

6.1 Sediment Grain Size Distribution

Sediment samples were collected from all 18 of the sediment grab sampling stations during the April 2022 survey. Water depths at the sediment sampling stations ranged from 10.0 to 27.5 feet. Grain sizes were very similar throughout the survey area, with all samples being composed predominately of sand (97.3% to 98.6%) with trace silt and clay (1.4% to 2.5%) and little to no gravel (0.0% to 0.2%) (Exhibit 6-1, Figure 6-1). See Map 1 for a visual representation of spatial relationships. See the full laboratory report in Appendix D for further details. Appendix C includes field photographs of the sediment samples.

Grain size distributions appear analogous within and outside the proposed nearshore placement area based on survey results (Exhibit 6-2).

Exhibit 6-1. Sediment Grain Size Distribution Summary Per Station

Station ID	Relationship to Nearshore Placement Area	Sediment Composition		
		% Gravel	% Sand	% Silt & Clay
MI-01	Inside placement area	0.1	98.2	1.8
MI-02		0.0	98.0	2.0
MI-03		0.1	97.9	2.0
MI-04		0.0	98.5	1.5
MI-05		0.0	97.6	2.4
MI-06		0.0	98.2	1.8
MI-07		0.0	98.5	1.5
MI-08		0.2	97.3	2.5
MI-09	East of placement area	0.1	98.4	1.5
MI-10	East of placement area	0.0	97.5	2.5
MI-11	East of placement area	0.0	97.7	2.3
MI-12	South of placement area	0.0	97.5	2.4
MI-13	South of placement area	0.1	98.1	1.8
MI-14	South of placement area	0.2	97.8	2.1
MI-15	North of placement area	0.0	98.0	2.0
MI-16	West of placement area	0.0	98.6	1.4
MI-17	South of placement area	0.0	98.0	2.0
MI-18	East of placement area	0.1	98.3	1.7

Notes: Particle sizes: gravel ≥4.750 mm, sand = 0.075–4.749 mm, silt & clay <0.075 mm. See Table 4 for full results.

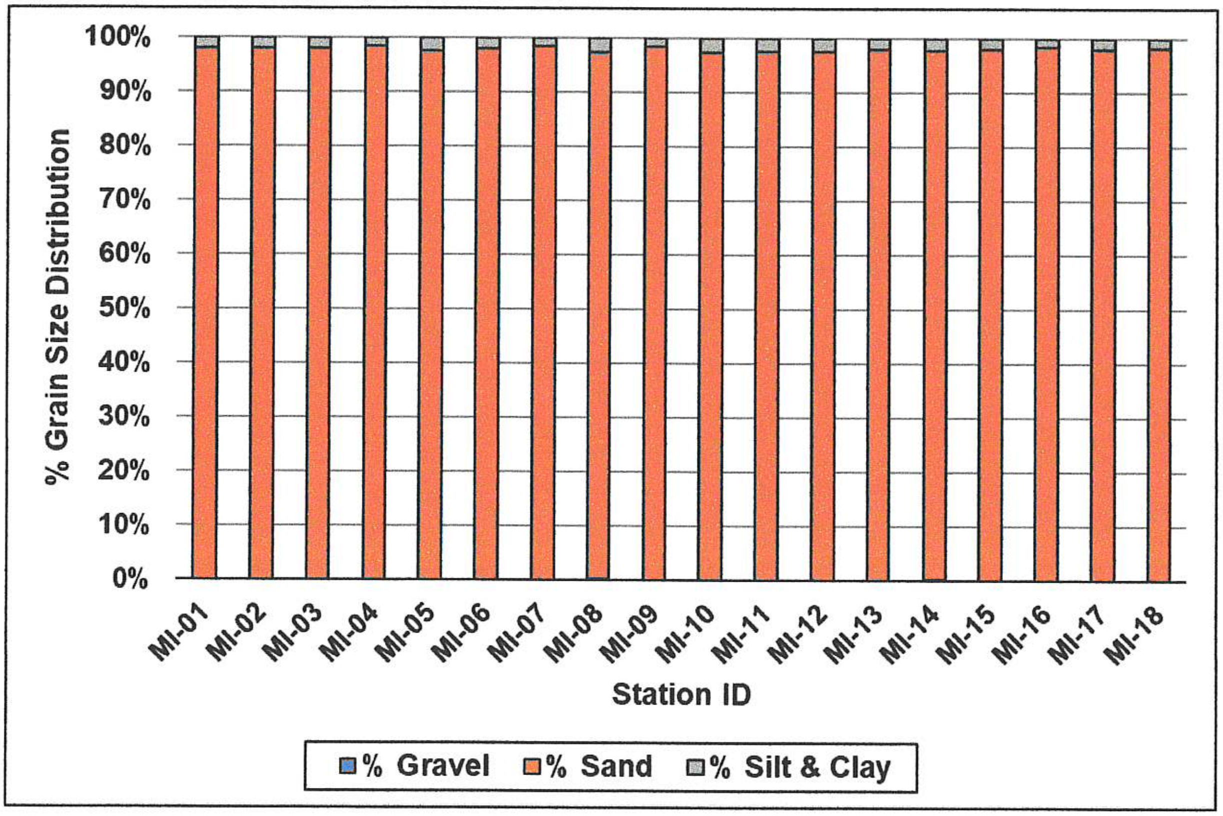


Figure 6-1. Grain Size Distribution Per Station

Notes: Particle sizes: gravel ≥4.750 mm, sand = 0.075–4.749 mm, silt & clay <0.075 mm. See Table 4 for full results.

Exhibit 6-2. Mean Sediment Grain Size Distribution Inside and Outside the Nearshore Placement Area

Area	% Gravel (Mean [± SD])	% Sand (Mean [± SD])	% Silt & Clay (Mean [± SD])
Inside placement area	0.05 (± 0.07)	98.0 (± 0.39)	1.9 (± 0.35)
Outside placement area	0.05 (± 0.07)	98.0 (± 0.35)	2.0 (± 0.35)

Notes: Particle sizes: gravel ≥4.750 mm, sand = 0.075–4.749 mm, silt and clay <0.075 mm. See Table 4 for full results.

6.2 Sediment Chemistry

Sediment samples collected from stations MI-01, MI-08, MI-10, MI-16, and MI-18 underwent chemistry analysis. Sediment collected from stations MI-01 and MI-08 were collected from inside the placement area with the remaining stations located outside the placement area.

Analyses consisted of metals, total solids, total organic carbon (TOC), ammonia, total petroleum hydrocarbons (TPHs), pesticides, PAHs, and PCB congeners. Analytical results were compared to published sediment screening criteria TEL and ERL, which are defined in Subsection 5.1. The CQAR is in Appendix E and the chemistry laboratory report is in Appendix F.

6.2.1 Metals, Total Solids, TOC, Ammonia and TPHs

Most analyzed metals were detected in concentrations greater than the MDL in most sediment samples, except for cadmium, mercury, and thallium, which were not detected above the MDL in any sample (Exhibit 6-3). Sample MI-08 contained the maximum detected concentrations for four (44%) of the nine metals detected. None of the metals results exceeded the TEL or ERL.

Total solids ranged from 72.2% to 76.5% and was highest in MI-16. TOC ranged from 2240 to 4730 mg/kg and was highest in MI-08. Ammonia (as nitrogen) concentrations ranged from 13.3 to 24.4 mg/kg and was highest in MI-10. TPHs were not detected above the MDL (U-qualified) in any sample tested. Complete results are in Tables 5 and 6.

Concentrations of metal, total solids, TOC, ammonia, and TPH were similar inside the placement area versus outside this area (Exhibit 6-4). Although the stations within the placement area included maximum concentrations of five of the nine metals detected, the results are not substantially greater than outside the placement area.

Exhibit 6-3. Sediment Metal, Total Solids, TOC, and Ammonia Concentrations Per Station Excluding Non-detected Analytes

Analyte	Concentration (mg/kg or as otherwise indicated)						
	Inside Placement Area		Outside Placement Area				
	MI-01	MI-08	MI-10	MI-16	MI-18	TEL	ERL
METALS							
Antimony	0.976	0.773	0.828	0.620	0.518	x	x
Arsenic	1.19	2.26	1.88	1.24	2.36	7.24	8.2
Beryllium	0.105	0.179	0.115	0.140	0.142	x	x
Chromium	7.72	10.1	8.02	10.7	8.54	52.3	81
Copper	0.187	0.383	0.288	0.206	0.291	18.7	34
Lead	2.33	2.91	2.14	3.26	2.35	30.24	46.7
Nickel	0.657	1.07	0.762	0.831	0.884	15.9	20.9
Selenium	0.471	0.572	<1.21	0.623	<1.38	x	x
Zinc	4.78	7.58	6.59	7.26	6.56	124	150
OTHERS							
Solids, Total (%)	73.7	72.7	72.2	76.5	72.3	x	x
TOC (mg/kg)	2240	4730	4310	4690	3690	x	x
Ammonia (as N) (mg/kg)	14.3	23.7	25.0	13.3	24.4	x	x

"<" less-than symbol indicates the analyte concentration was not detected above the MDL (U-qualified). Value indicates the LRL.

x = No TEL or ERL published for that parameter.

See Tables 5 and 6 for complete results.

Exhibit 6-4. Sediment Metal, Total Solids, TOC, and Ammonia Concentrations Inside and Outside the Placement Area Excluding Non-detected Analytes

Analyte	Range of Values (µg/kg or as otherwise indicated)	
	Inside Placement Area (MI-01 and MI-08)	Outside Placement Area (MI-10, MI-16, and MI-18)
METALS		
Antimony	0.773–0.976	0.518–0.828
Arsenic	1.19–2.26	1.24–2.36
Beryllium	0.105–0.179	0.115–0.142
Chromium	7.72–10.1	8.02–10.7
Copper	0.187–0.383	0.206–0.291
Lead	2.33–2.91	2.14–3.26
Nickel	0.657–1.07	0.762–0.884
Selenium	0.471–0.572	0.623–<1.38
Zinc	4.78–7.58	6.59–7.26
OTHERS		
Solids, Total (%)	72.7–73.7	72.2–76.5
TOC (mg/kg)	2240–4730	3690–4690
Ammonia (as N) (mg/kg)	14.3–23.7	13.3–25.0

"<" less-than symbol indicates the analyte concentration was not detected above the MDL (U-qualified). Value indicates the LRL.

See Tables 5 and 6 for complete results.

6.2.2 Pesticides

Of the 24 pesticides, only (trans)-chlordane was detected in concentrations above the MDL, and only in sample MI-08 and below the LRL (J-qualified). All other results were below the MDL (U-qualified). The LRLs associated with U-qualified results for p,p' (4,4')-DDD; p,p' (4,4')-DDT; and γ-BHC (lindane) in all samples exceeded the respective TEL and (or) ERL. The MDLs associated with U-qualified results for technical chlordane, dieldrin, and toxaphene in all samples exceeded the respective TEL and (or) ERL. The MDLs for all pesticides were below the target detection limits in Table 8-2 of the SAP. The LRLS for all pesticides tested were above the laboratory reporting limits in Table 8-2 of the SAP.

Total pesticides, calculated from the MDLs for the U-qualified results, ranged from 15.5 to 16.5 µg/kg and was highest in sample MI-10. Results inside the placement area and outside this area were similar. See Table 7 for complete results.

6.2.3 PAHs

Four of the 18 PAH analytes tested—benzo(b)fluoranthene, chrysene, fluoranthene, and pyrene—were detected above the MDL but below the LRL (J-qualified), and only in sample MI-08. No other PAHs were detected above the MDL (U-qualified) in any sample tested. Total PAHs, calculated from MDLs for U-qualified results, ranged from 18.5 to 24.0 µg/kg. None of the PAH results exceeded the TEL or ERL. See Table 8 for complete results.

All four of the detected PAHs were from within the placement area. No other differences were observed for results inside the placement area and outside this area.

6.2.4 PCB Congeners

None of the 26 PCB congeners tested were detected above the MDL (U-qualified) in any sample tested. Total EPA Region 4 congeners, calculated from the LRL values, ranged from 8.7 to 9.6 µg/kg and were highest in samples MI-08 and MI-10 (Exhibit 6-5). Total NOAA PCB congeners ranged from 11.3 to 12.5 µg/kg and were highest in sample MI-10. None of the results exceeded the TEL or ERL.

The range of total PCBs were similar inside the placement area and outside this area (Exhibit 6-6).

Exhibit 6-5. Sediment Total PCB Concentrations Per Station

	Inside Placement Area		Outside Placement Area				
Analyte Group	MI-01 (µg/kg)	MI-08 (µg/kg)	MI-10 (µg/kg)	MI-16 (µg/kg)	MI-18 (µg/kg)	TEL (µg/kg)	ERL (µg/kg)
Total EPA Reg. 4 PCBs*	8.8	9.6	9.6	8.7	9.4	21.6	22.7
Total NOAA PCBs*	11.5	12.4	12.5	11.3	12.1	21.6	22.7

* See SERIM Section 7.3 for details on total EPA Region 4 PCBs and total NOAA PCBs.
See Table 9 for complete results.

Exhibit 6-6. Sediment Total PCB Concentrations Inside and Outside the Placement Area

	Range of Values per Area (µg/kg)	
Analyte Group	Inside Placement Area (MI-01 and MI-08)	Outside Placement Area (MI-10, MI-16, and MI-18)
Total EPA Reg. 4 PCBs*	8.8–9.6	8.7–9.6
Total NOAA PCBs*	11.5–12.4	11.3–12.5

* See SERIM Section 7.3 for details on total EPA Region 4 PCBs and total NOAA PCBs.
See Table 9 for complete results.

6.3 Water Physicochemical Parameters

Water physicochemical parameters were recorded during April 12 and 13, 2022, at stations MI-01, 08, 10, 16, and 18 using a YSI multimeter. Water temperature, pH, salinity, specific conductivity, and dissolved oxygen were collected approximately 1 meter off the bottom. Turbidity was measured at the water's surface. Table 3 contains spatial coordinates and complete physicochemical results.

Surface turbidity ranged from 1.64 to 6.63 NTUs throughout the survey area (Exhibit 6-7). Most water parameters varied only slightly during the survey. This was true for temperature (17.9°–18.4° C), salinity 33.20–33.34 ppt, conductivity (50541–50729 µS/cm), and DO (93.5%–104.5% [7.25–8.01 mg/L]). pH ranged from a low of 7.40 (at station MI-01) to a high of 8.04 (at MI-16).

Exhibit 6-7. Water Parameters Per Station and Inside and Outside the Nearshore Placement Area

Parameter	Inside Placement Area		Outside Placement Area			Inside Placement Area	Outside Placement Area
	MI-01	MI-08	MI-10	MI-16	MI-18		
Turbidity at surface (NTU)	6.17	3.00	3.22	6.63	1.64	3.00–6.17	1.64–6.63
Depth of reading (ft)	11	17	24	9	25	11–17	9–25
Temperature (°C)	17.9	17.9	18.4	18.4	18.3	17.9–17.9	18.3–18.4
pH	7.40	8.03	8.00	8.04	8.00	7.40–8.03	8.00–8.04
Salinity (ppt)	33.28	33.34	33.20	33.33	33.23	33.28–33.34	33.20–33.33
Conductivity (µS/cm)	50646	50729	50541	50704	50590	50646–50729	50541–50704
DO (mg/L)	7.25	7.75	7.35	8.01	7.36	7.25–7.75	7.35–8.01
DO (% saturation)	93.5	100	95.3	104.5	94.9	93.5–100	94.9–104.5

6.4 Benthic Infauna

Infaunal samples were collected during April 12–14, 2022, in triplicate from each of the 18 grab sampling stations (MI-01 through MI-18). Eight stations were within the proposed nearshore placement area and 10 stations were located outside (north, south, east, and west) of the placement area (Exhibit 6-8). Field observations during grab sampling, including infaunal sampling, are summarized in Table 1. Copies of field logs are in Appendix B. The benthic infaunal raw data, community indices, and statistical comparisons provided by the lab are in Appendix G.

Exhibit 6-8. Benthic Infaunal Samples Inside and Outside the Nearshore Placement Area

Area	Numbers of Stations and Samples	Water Depths (ft)
Inside placement area	8 stations x 3 pseudo-replicates = 24 samples	Range = 14.5–23.5 Mean = 18.9
Outside placement area	10 stations x 3 pseudo-replicates = 30 samples	Range = 10.0–27.5 Mean = 20.3

6.4.1 Relative Abundance (Density)

Mean relative abundance, expressed as the number of individuals per square meter averaged between three pseudo-replicates, ranged from 700.0 (± 478.9 SD) to 8,483.3 (± 1417.8 SD) and was highest at station MI-11 (Exhibit 6-9). Both the minimum and maximum values were from stations outside the placement area. In general, high abundance values were observed at the deepest stations sampled.

The mean of samples inside the placement area (3467.7 [± 2052.9 SD] individuals/m^2) was less than that of outside this area (5205.8 [± 3070.6 SD] individuals/m^2) (Exhibit 6-10). A statistical comparison was conducted using a two-tailed *t*-test and the difference was found to be statistically significant (*t* statistic = 2.483, *p*-value = 0.016) (Exhibit 6-11) and the result remained significant following treatment with a Kruskal-Wallis test to account for the lack of normality (*p*-value = 0.025).

Exhibit 6-9. Benthic Infaunal Relative Abundance (Density) Per Station

Station ID	Relationship to Nearshore Placement Area	Mean Abundance (individuals/m^2)	Standard Deviation
MI-01	Inside placement area	4233.3	1331.7
MI-02		3950.0	845.2
MI-03		1658.3	434.7
MI-04		3275.0	2663.1
MI-05		1600.0	378.3
MI-06		4341.7	1894.9
MI-07		1925.0	377.5
MI-08		6758.3	1561.3
MI-09	East of placement area	5516.7	1002.6
MI-10	East of placement area	7958.3	2878.6
MI-11	East of placement area	8483.3	1417.8
MI-12	South of placement area	4800.0	541.4
MI-13	South of placement area	7333.3	4006.4
MI-14	South of placement area	2383.3	80.4
MI-15	North of placement area	700.0	478.9
MI-16	West of placement area	3091.7	1330.0
MI-17	South of placement area	4050.0	676.4
MI-18	East of placement area	7741.7	3345.3

Exhibit 6-10. Benthic Infaunal Relative Abundance Inside and Outside the Nearshore Placement Area

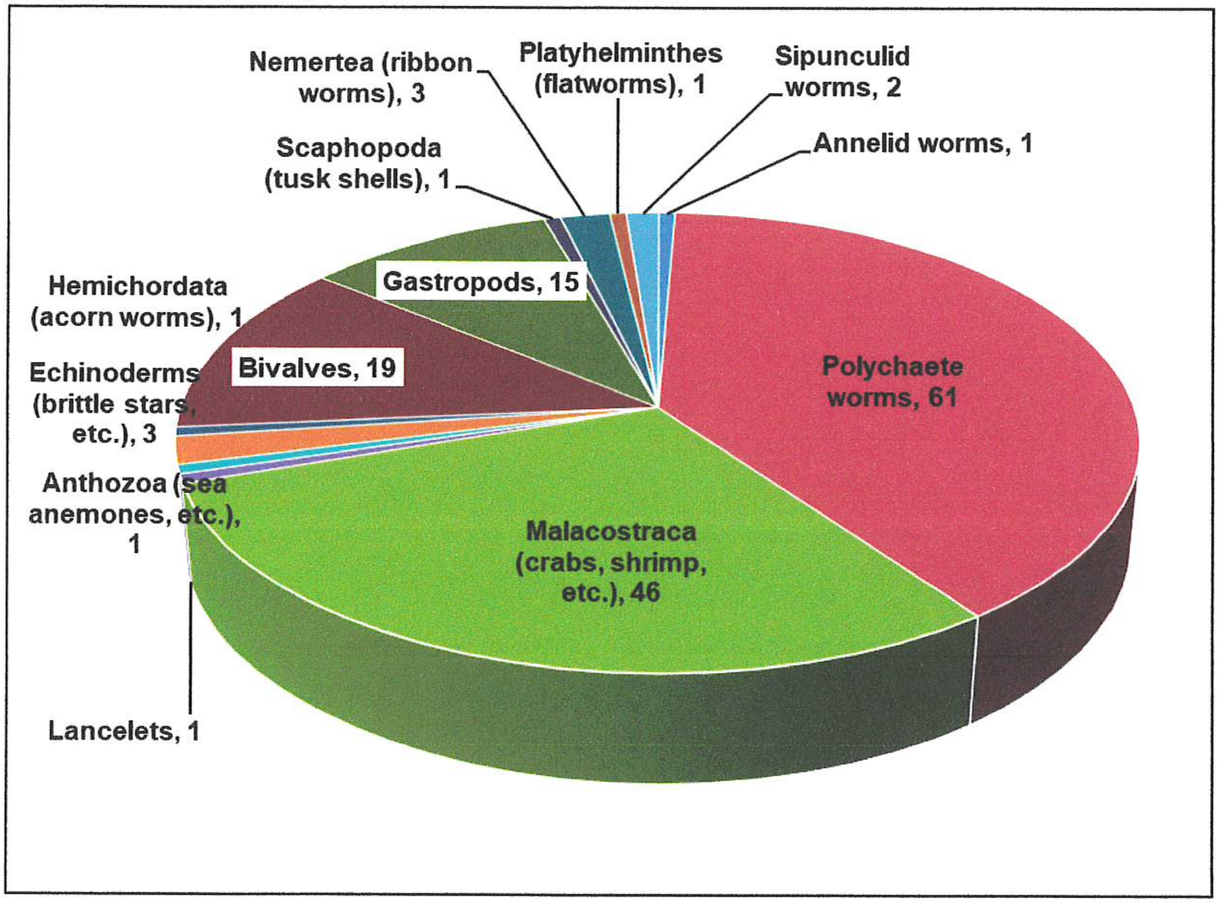
Area	Total Mean Infaunal Abundance (individuals/m^2)	Standard Deviation
Inside placement area	3467.7	2052.9
Outside placement area	5205.8	3070.6

Exhibit 6-11. Statistical Comparison of Relative Abundance Inside and Outside the Nearshore Placement Area

Parameter	Inside Placement Area	Outside Placement Area
***t*-Test Assuming Unequal Variances**		
Mean abundance (individuals/ m^2)	3467.7	5205.8
Variance	4214591.3	9428693.2
Observations (*n*)	24	30
Degrees of freedom	51	
t statistic	2.483	
t critical two-tail	2.008	
Alpha	0.050	
t-test *p*-value	0.016	
Significantly different?	**Yes** (*t* statistic > 2.008 and *p*-value < 0.05)	
Kruskal-Wallis Test (non-parametric test)		
Observations (*n*)	24	30
Median	2800	4737
Mean rank	22.1	31.8
Z-value	-2.24	2.24
p-value (H = 5.00, DF = 1)	0.025 (0.025 adjusted for ties)	
Significantly different accounting for lack of normality?	**Yes** (*p*-value < 0.05)	

6.4.2 Taxonomic Richness and Diversity

A total of 155 infaunal taxa were identified from the 54 samples collected during the survey. Polychaete worms dominated taxonomic richness, accounting for 61 taxa and 39% of all taxa identified (Figure 6-2). Crabs and shrimps numbered 46 taxa and represented 30% of all taxa identified. Other infaunal groups having notable taxonomic richness consisted of bivalves (19 taxa, 12% of all taxa) and gastropods (15 taxa, 10% of all taxa). Benthic infaunal taxa and community index results from the laboratory are in Appendix G.



155 identified infaunal taxa by major taxonomic group
(includes all grab samples from inside and outside the placement area)

Figure 6-2. 155 Identified Infaunal Taxa by Major Taxonomic Group

Note: this includes all grab samples from all stations.

The mean number of taxa per station ranged from 10.0 (± 3.6 SD) to 40.7 (± 13.3 SD) and was highest at station MI-11 (Exhibit 6-12). Total number of taxa per station ranged from 21 to 67 and was highest at MI-11. The total number of individuals per station ranged from 84 to 1018 and was highest at station MI-11. Shannon diversity index values per station ranged from 1.66 (at station MI-13) to 3.48 (at station MI-04). Pielou taxonomic evenness index values per station ranged from 0.42 (at station MI-13) to 0.85 (at MI-04).

The Shannon diversity index is commonly used to measure biological diversity by accounting for numbers of taxa represented in a given sample and evenness of the distribution of individuals across taxa within that sample. The scores derived from this index fit within a range of 0 to 5 (normally 1.5 to 3.5), with scores of less than 1 suggesting relatively polluted and degraded habitat and scores higher than 3 considered indicative of stable and balanced habitat (Türkmen and Kazanci 2010). The Pielou evenness index is essentially derived from the Shannon index and operates on a scale of 0 to 1 (Pielou 1966). The closer the Pielou index value is to 1, the greater the distribution of individuals among taxa represented in samples (Pielou 1966).

Exhibit 6-12. Mean Infaunal Taxonomic Richness, Diversity and Evenness Per Station

Station ID	Mean Number of Taxa	Standard Deviation	Total Number of Taxa	Total Number of Individuals (*n*)	H' Shannon Diversity Index	J' Pielou Evenness Index
MI-01	24.7	6.8	43	508	2.29	0.61
MI-02	21.3	4.7	34	474	2.12	0.60
MI-03	21.7	3.2	39	199	2.87	0.78
MI-04	31.7	15.9	59	393	3.48	0.85
MI-05	14.3	1.5	25	192	2.24	0.70
MI-06	28.7	5.1	53	521	2.48	0.62
MI-07	22.3	2.9	37	231	2.64	0.73
MI-08	35.3	7.1	61	811	2.61	0.64
MI-09	27.0	2.6	48	662	2.15	0.56
MI-10	31.3	2.5	54	955	1.96	0.49
MI-11	40.7	13.3	67	1018	2.15	0.51
MI-12	32.7	2.5	54	576	2.45	0.61
MI-13	28.7	5.1	53	880	1.66	0.42
MI-14	24.3	2.3	42	286	2.72	0.73
MI-15	10.0	3.6	21	84	2.25	0.74
MI-16	17.7	3.5	31	371	2.36	0.69
MI-17	29.0	1.0	53	486	2.53	0.64
MI-18	36.0	3.0	63	929	2.38	0.57

The mean number of taxa per sample was greatest outside the placement area (27.7 [± 9.5 SD]) compared to inside this area (25.0 [± 8.8 SD]) (Exhibit 6-13). The mean number of taxa per station was also greater outside the placement area (48.6 [± 14.0 SD]) compared to inside this area (43.8 [± 12.7 SD]). The Shannon diversity index mean value per sample was highest inside the placement area (2.59 [± 0.44 SD]) compared to outside this area (2.26 [± 0.30 SD]) (Figure 6-3). The Pielou evenness index mean value per sample was higher inside the placement area (0.69 [± 0.09 SD]) compared to outside this area (0.60 [± 0.11 SD]). However, the differences in the means of total number of taxa, Shannon diversity, and Pielou evenness were determined to be statistically insignificant based on the results of two-tailed *t*-tests conducted (Exhibits 6-14 through 6-16).

Exhibit 6-13. Mean Infaunal Diversity, Evenness and Taxonomic Richness Inside and Outside the Nearshore Placement Area

Area	Mean Number of Taxa Per Sample (± SD)	Mean Total Number of Taxa Per Station (± SD)	H' Shannon Diversity Index Mean Value Per Sample (± SD)	J' Pielou Evenness Index Mean Value Per Sample (± SD)
Inside placement area	25.0 (± 8.8)	43.8 (± 12.7)	2.59 (± 0.44)	0.69 (± 0.09)
Outside placement area	27.7 (± 9.5)	48.6 (± 14.0)	2.26 (± 0.30)	0.60 (± 0.11)

Exhibit 6-14. Statistical Comparison of Total Number of Infaunal Taxa Per Station Inside and Outside the Nearshore Placement Area

Parameter	Inside Placement Area	Outside Placement Area
***t*-Test Two-Sample Assuming Unequal Variances**		
Mean number of taxa per station	43.9	48.6
Variance	161.6	195.4
Observations (*n*)	8	10
Degrees of freedom	16	
t statistic	0.750	
t critical two-tail	2.120	
Alpha	0.050	
t-test *p*-value	0.464	
Significantly different?	**No** (*t* statistic < 2.120 and *p*-value > 0.05)	

Exhibit 6-15. Statistical Comparison of Infaunal H' Shannon Diversity Inside and Outside the Nearshore Placement Area

Parameter	Inside Placement Area	Outside Placement Area
***t*-Test Two-Sample Assuming Unequal Variances**		
Mean H' Shannon diversity index value	2.59	2.26
Variance	0.19	0.09
Observations (*n*)	8	10
Degrees of freedom	12	
t statistic	1.825	
t critical two-tail	2.179	
Alpha	0.050	
t-test *p*-value	0.093	
Significantly different?	**No** (*t* statistic < 2.179 and *p*-value > 0.05)	

Exhibit 6-16. Statistical Comparison of Infaunal J' Pielou Evenness Inside and Outside the Nearshore Placement Area

Parameter	Inside Placement Area	Outside Placement Area
***t*-Test Two-Sample Assuming Unequal Variances**		
Mean J' Pielou evenness index value	0.69	0.60
Variance	0.01	0.01
Observations (*n*)	8	10
Degrees of freedom	16	
t statistic	2.060	
t critical two-tail	2.120	
Alpha	0.050	
t-test *p*-value	0.056	
Significantly different?	**No** (*t* statistic < 2.120 and *p*-value > 0.05)	

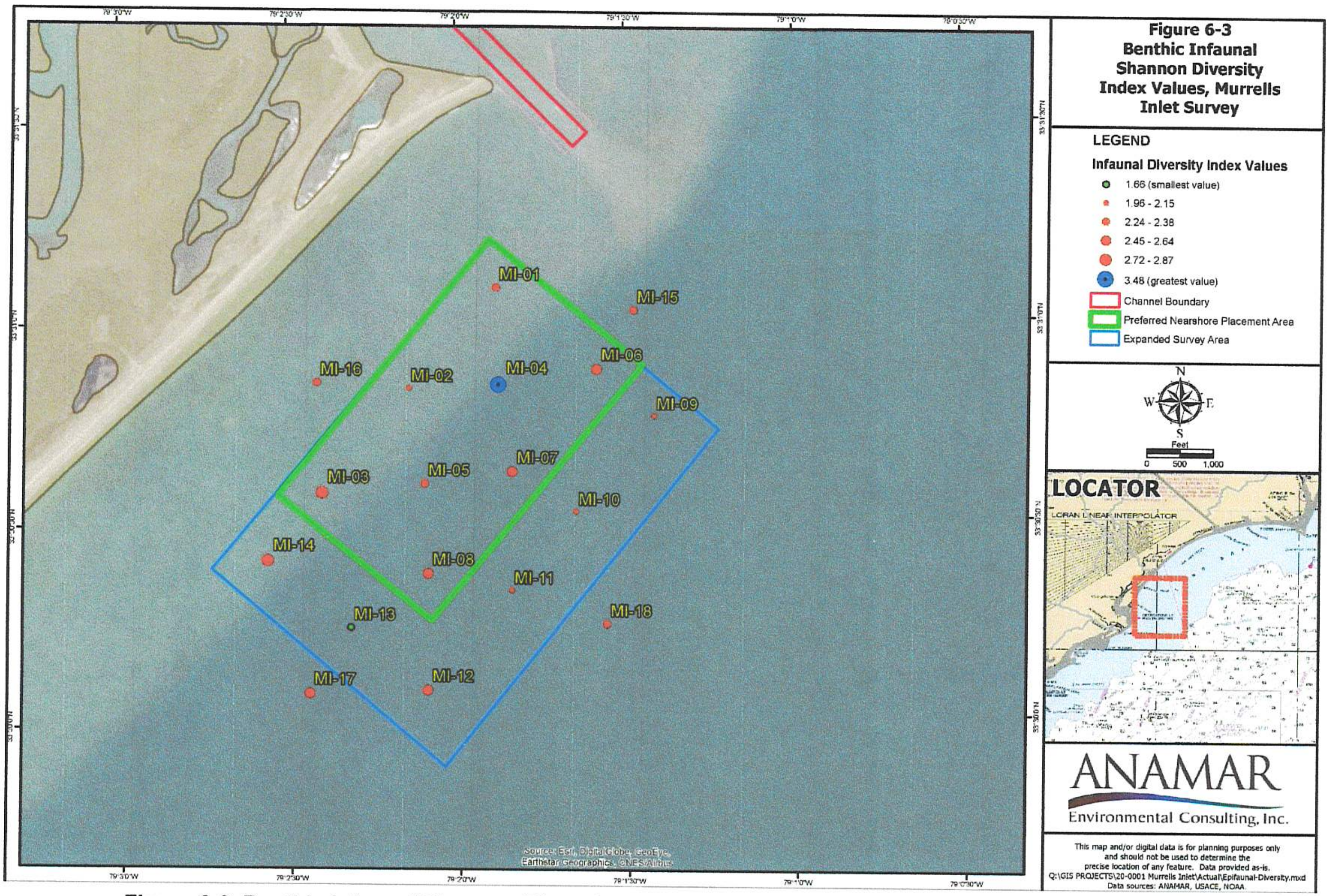


Figure 6-3. Benthic Infaunal Shannon Diversity Values Mapped Per Station, April 2022 Survey Results

Note: this includes all grab samples from all stations.

6.4.3 Community Structure

The infaunal community in and around the placement area is complex and species-rich based on the samples collected during the survey. The following are examples of some of the important taxonomic groups represented. The polychaete worms were species-rich and included *Amastigos caperatus*, *Clymenella torquata*, and *Spiophanes bombyx* among the most common species represented in samples. Crustaceans were important components of infaunal samples and included the amphipods *Acanthohaustorius intermedius*, *Eudevenopus honduranus*, and *Protohaustorius wigleyi*. Bivalves were also important components of infaunal samples and included *Pythinella cuneata*, and members of the families Semelidae and Tellinidae. Gastropods were taxa-rich in samples and included the bubble snail species *Acteocina candei*, the slipper snail genus *Crepidula*, and the pyram genus *Turbonilla* sp. These and other benthic infaunal taxa are prey to larger epibenthic invertebrates along with epibenthic/demersal fish species. Many benthic infaunal organisms produce pelagic eggs and larvae which are important food for pelagic fishes such as anchovies (Engraulidae) and herrings (Clupeidae) while the larger pelagic larvae feed larger pelagic fishes. A complete taxonomic list of infaunal invertebrates identified from the survey samples is in Appendix G.

6.5 Trawled Epifauna

Epifaunal trawl samples were collected on April 16, 2022. Three trawl stations were conducted within the proposed nearshore placement area in water depths of 19 to 26 feet, and four stations were sampled outside this area in water depths of 15 to 28 feet. Trawl stations are depicted in Map 2. Trawl sampling areas are summarized per station in Exhibit 6-17 and within and outside the placement area in Exhibit 6-18.

Exhibit 6-17. Trawl Sampling Area per Trawl Station

Station ID	Location in Relative to the Proposed Nearshore Placement Area	Estimated Area Sampled (m^2)
MI-TR-01	Inside placement area	5655.0
MI-TR-02		5215.8
MI-TR-03		5186.7
MI-TR-04	East of placement area	5223.8
MI-TR-05	West of placement area	5214.6
MI-TR-06 (tow #1)	South of placement area	5195.9
MI-TR-06 (tow #2)	South of placement area	5184.3
MI-TR-07	East of placement area	5236.8

Exhibit 6-18. Trawl Sampling Effort Inside and Outside the Nearshore Placement Area

Area Sampled Inside Placement Area (m^2, number of tows)	Area Sampled Outside Placement Area (m^2, number of tows)	Total Area Sampled (m^2, number of tows)
16,057.5 m^2 trawled (3 tows)	26,055.3 m^2 trawled (5 tows *)	42,112.8 m^2 trawled (8 tows *)

* Station MI-TR-06 was sampled twice. Both of these trawl samples are included above.

Based on trawl contents along with evidence of gear wear, all tows had contact with the seafloor during trawling. Trawl station MI-TR-06 had a relatively small catch and this station was sampled a second time during the same day in case the small catch was due to poor contact with the seafloor. Sample biomass and species composition were similar between the two trawl samples collected from station MI-TR-06, suggesting that sample contents may simply reflect a paucity of epibenthic fauna at this location rather than poor contact with the seafloor. This station is positioned farther away from the south jetty of Murrells Inlet compared to the remaining stations.

6.5.1 Wet Weight Biomass

Total epifaunal wet weight biomass was measured following each trawl sample and included fish, invertebrate, and some marine algae (drift algae, some sargassum weed). For comparison purposes, biomass values were normalized to kg per 1,000 m^2 sampled. The highest biomass (4.2 kg) was found at trawl station MI-TR-04, the eastern-most and farthest offshore station (Exhibit 6-19, Figure 6-4). The lowest biomass (0.1 kg) was found at MI-TR-06 for the two tows conducted there. This station farthest south and farthest away from the south jetty and inlet and may have less resources for epifaunal species than those trawl stations sampled closer to the south jetty.

Biomass (kg/1,000 m^2) for trawl samples within the proposed nearshore disposal site ranged from 1.4 to 2.3 kg while those outside the placement area ranged from 0.1 to 4.2 kg and had the lowest and the highest biomass of the survey. This may be due to the relatively wide area, depth distribution, and varied distances sampled from the nearest structure (the south jetty) compared to the smaller, less varied benthic habitat within the placement area.

The mean biomass (kg/1,000 m^2) per trawl sample inside the placement area (1.8 kg) was comparable to the mean outside this area (1.8 kg) (Exhibit 6-20). The biomass values per station inside the placement area and outside this area are not statistically significant based on the results of a two-tailed *t*-test (t statistic < 2.78, p-value = 0.96) (Exhibit 6-21).

Exhibit 6-19. Epifaunal Wet Weight Biomass Per Trawl Sample

Sample ID	Location Relative to Nearshore Placement Area	Total Wet Weight Biomass (kg/1,000 m^2)
MI-TR-01	Inside placement area	1.4
MI-TR-02		1.6
MI-TR-03		2.3
MI-TR-04	East of placement area	4.2
MI-TR-05	West of placement area	0.9
MI-TR-06 (tow #1)	South of placement area	0.1
MI-TR-06 (tow #2)		0.1
MI-TR-07	East of placement area	2.2
	INSIDE MEAN	**1.8**
	OUTSIDE MEAN	**1.8**
	OVERALL MEAN	**1.8**

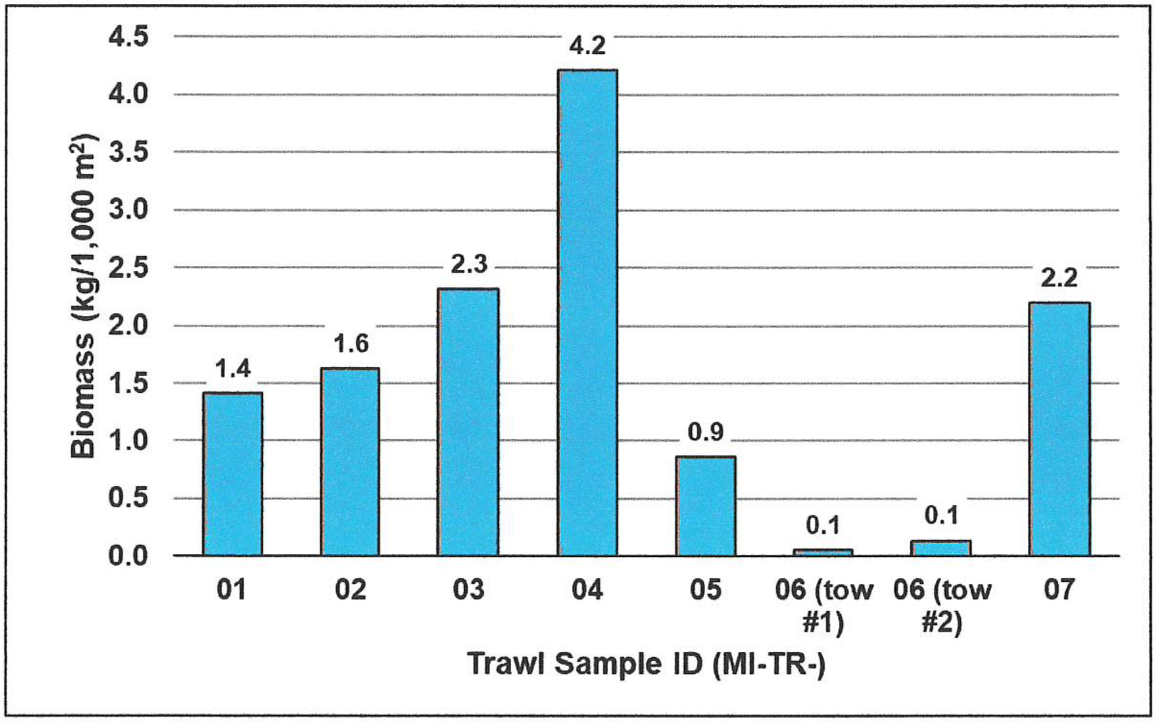


Figure 6-4. Wet Weight Biomass per Trawl Sample

Exhibit 6-20. Epifaunal Biomass Inside and Outside the Nearshore Placement Area

Area	Total Wet Weight Biomass (kg/1,000 m^2)	
	Mean of Trawl Samples	Range of Samples
Inside Placement Area	1.8	1.4–2.3
Outside Placement Area	1.8	0.1–4.2

Exhibit 6-21. Statistical Comparison of Epifaunal Biomass Inside and Outside the Nearshore Placement Area

Parameter	Inside Placement Area	Outside Placement Area
***t*-Test Two-Sample Assuming Unequal Variances**		
Mean Biomass (kg/1,000 m^2)	1.79	1.83
Variance	0.22	3.29
Observations (*n*)	3	4
Degrees of freedom	4	
t statistic	-0.049	
t critical two-tail	2.78	
Alpha	0.050	
t-test *p*-value	0.96	
Significantly different?	**No** (*t* statistic < 2.78 and *p*-value > 0.05)	

6.5.2 Taxonomic Richness and Diversity

A total of 138 trawled invertebrates belonging to 11 taxa were collected and represented six major groups (Figure 6-4). The arthropods dominated the invertebrate groups and were represented in trawl samples by six species of crabs and shrimps. Some invertebrates found in trawl samples are not strictly associated with the seafloor and were therefore omitted from further comparative analyses. These taxa consisted of comb jellies (ctenophores), cannonball jellyfish (*Stomolophus meleagris*), and the inshore squid genus *Loligo* sp.

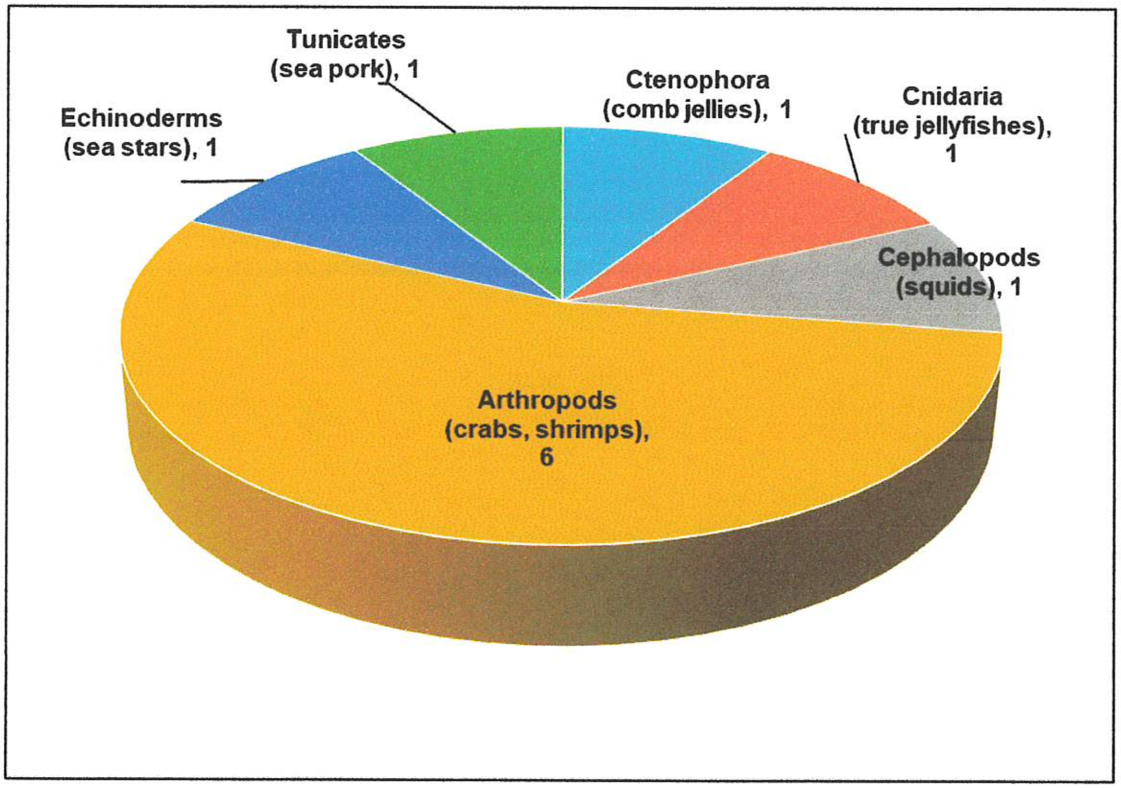


Figure 6-5. Eleven Identified Trawled Invertebrate Genera by Major Taxonomic Group

Note: This includes all trawl samples

Four stations shared the highest number of invertebrate taxa per trawl sample (7 taxa). These stations were both inside (stations MI-TR-02 and 03) and outside the placement area (stations MI-TR-05 and 07) (Exhibit 6-22). Station MI-TR-06 had the lowest number of taxa, with only one to two invertebrate taxa per trawl sample collected there. This station is located farthest away from the south jetty.

Exhibit 6-22. Phylogenetic List of Invertebrate Taxa Per Trawl Sample

	Individuals per Trawl Sample (MI-TR-)							
Scientific Name (Common Name)	**01**	**02**	**03**	**04**	**05**	**06 (tow #1)**	**06 (tow #2)**	**07**
Ctenophora (comb jelly)	2							2
Stomolophus meleagris (cannonball jellyfish)	7	9	5	8	5		1	4
Loligo sp. (an inshore squid)	8	3	21	11	6			12
Aegathoa oculata (a parasitic isopod)		1	1	1		1		
Litopenaeus setiferus (white shrimp) (Figure 6-6)	2	1		1	2			3
Paguristes sp. (a hermit crab)		1	1	1	1			1
Libinia emarginata (portly spider crab)	1		1		1			1
Portunus gibbesii (iridescent swimming crab)		2			1			
Leptodius sp. (a mud crab)			1					
Luidia clathrata (lined sea star)					1		2	1
Aplidium cf. *constellatum* (sea pork)		1	5					
TOTAL INDIVIDUALS PER STATION	**20**	**18**	**35**	**22**	**17**	**1**	**1**	**24**
TOTAL TAXA PER SAMPLE	**5**	**7**	**7**	**5**	**7**	**1**	**1**	**7**

Note: Phylogeny and scientific names generally follow World Register of Marine Species (WORMS) (www.marinespecies.org).

Trawl-sampled fishes totaled 1,618 and represented 14 species. Fishes as a group included nine families representing six orders based on phylogeny in Nelson (2006). The order Perciformes was the most species rich (five species, 43% of all fish species collected) (Figure 6-5). Most fishes captured were epibenthic/demersal species. Some were pelagic species and were excluded from epifaunal community indices. Non-epibenthic/demersal species consisted of the striped anchovy (*Anchoa hepsetus*), menhaden (*Brevoortia* species), and the butterfish (*Peprilus triacanthus*). Juvenile butterfish are known to associate with cannonball jellyfish (*Stomolophus meleagris*) and so the juvenile butterfish that were captured were likely associated with the jellyfish that were also captured during the survey.

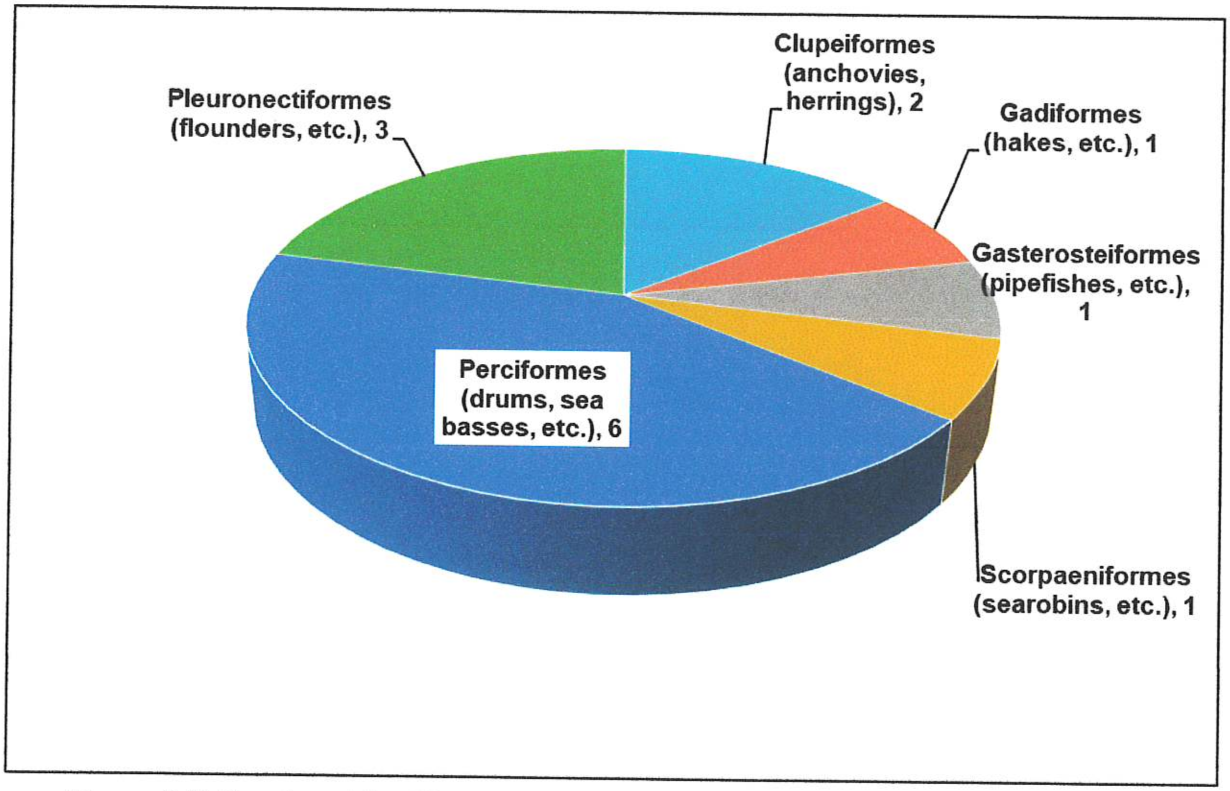


Figure 6-6. Fourteen Identified Trawled Fish Species by Major Taxonomic Group

Note: this includes all trawl samples

Fish species were dominated by drums (Sciaenidae). Of the four drum species present in trawl samples, the Atlantic croaker was by far the most collected during the survey. Up to 374 individual Atlantic croaker (*Micropogonias undulatus*) was found in a single trawl sample [MI-TR-04]) (Exhibit 6-23). This species was present in every trawl sample.

Station MI-TR-04 had the highest number of fish species recorded (10 species) of any station sampled. This station was east of the placement area. This station was in relatively deeper water than the other trawl stations, except for MI-TR-07, which had the second highest number of fish species (seven species). Station MI-TR-06 had the lowest number of fish species of any station, with only two to three fish species per trawl sample collected there. This station is located farthest away from the south jetty.

Exhibit 6-23. Phylogenetic List of Fish Species Per Trawl Sample

Scientific Name (Common Name)	Individuals per Trawl Sample (MI-TR-)							
	01	02	03	04	05	06 (tow #1)	06 (tow #2)	07
Anchoa hepsetus (striped anchovy)	310	45	80	25	130	4	4	85
Brevoortia sp. (menhaden)				1				
Urophycis regia (spotted hake)	2	3	2		1			
Syngnathus louisianae (chain pipefish)	2		3	1	1			
Prionotus scitulus (leopard searobin)		1	1	1				2
Centropristis striata (black sea bass)				1				
Larimus fasciatus (banded drum)			1	4				10
Leiostomus xanthurus (spot)	7	6	13	34	1			4
Micropogonias undulatus (Atlantic croaker)	51	58	115	374	26	6	2	187
Stellifer lanceolatus (star drum)			2	1				
Peprilus triacanthus (butterfish)	2		2	2	1			1
Ancylopsetta quadrocellata (ocellated flounder) (Figure 6-7)						1		
Citharichthys macrops (spotted whiff)		1						
Etropus crossotus (fringed flounder)								1
TOTAL INDIVIDUALS PER SAMPLE	**374**	**114**	**219**	**444**	**160**	**11**	**6**	**290**
TOTAL SPECIES PER SAMPLE	**6**	**6**	**9**	**10**	**6**	**3**	**2**	**7**

Notes: Phylogenetic relationships are simplified and follow Nelson (2006); Scientific and common names of species generally follow Page et al. (2013).

Total epifaunal densities (individuals/1,000 m^2) per trawl sample ranged from a high of 80.2 at station MI-TR-04 to a low of 0.8–1.5 at MI-TR-06 (Exhibit 6-24). The two highest densities were found at stations MI-TR-04 and MI-TR-07. Both stations are outside of the placement area.

Exhibit 6-24. Epifaunal Relative Abundance Per Trawl Station

Total Epifaunal Relative Abundance per Station ID, Listed by Rank		
Trawl Station ID	**Location Relative to Nearshore Placement Area**	**Total Epifaunal Abundance (individuals/1,000 m^2)**
MI-TR-01	Inside	11.5
MI-TR-02	Inside	14.4
MI-TR-03	Inside	28.1
MI-TR-04	East of placement area	80.2
MI-TR-05	West of placement area	6.7
MI-TR-06 (tow #1)	South of placement area	Mean 1.0 (range = 0.8–1.5)
MI-TR-06 (tow #2)		
MI-TR-07	East of placement area	40.1

Note: densities exclude pelagic species.

Mean total epifaunal relative abundance (individuals/1,000 m^2) per area were similar inside versus outside the placement area (Exhibit 6-25). The highest mean abundance was found outside the placement area, at 25.8 individuals/1,000 m^2 but ranged widely among the stations outside the placement area (0.8 to 80.2 individuals/1,000 m^2). The mean of 18.0 individuals/1,000 m^2 for inside the placement area fits within the range of values for outside this area, as does the range of values for each station within the placement area (11.5 to 28.1 individuals/1,000 m^2). Much of the epifaunal abundance can be attributed to the presence of Atlantic croaker, which dominated trawl catches in terms of frequency (found in every trawl sample) and numbers of individuals per sample.

Exhibit 6-25. Epifaunal Relative Abundance Inside and Outside the Nearshore Placement Area

Area	Total Epifaunal Abundance (individuals/1,000 m^2)	
	Mean of Trawl Samples	**Range of Trawl Samples**
Inside placement area	18.0	11.5–28.1
Outside placement area	25.8	0.8–80.2

Note: densities exclude pelagic species.

Lengths of fishes and white shrimp are summarized in Exhibit 6-26 below as standard length for fishes and post-orbital carapace length for shrimp. Examples of white shrimp and demersal fishes sampled by trawl are shown in Figures 6-6 and 6-7, respectively. Mean lengths inside and outside the placement area were similar for the species measured, except for the butterfish. The mean standard length for butterfish inside the placement area (47.5 mm, $n = 4$) was over twice the mean length for those caught outside this area (18.0 mm, $n = 2$). This can be explained by the low number of individuals (five butterfish) captured and subsequently measured.

Exhibit 6-26. Lengths of Fishes and White Shrimp Per Area

Scientific Name (Common Name)	Mean Length (mm) per Area		
	Inside Placement Area	Outside Placement Area	Overall
Litopenaeus setiferus (white shrimp [Figure 6-6])	22.3 (*n* = 7)	23.3 (*n* = 6)	22.8 (*n* = 13)
Anchoa hepsetus (striped anchovy)	47.7 (*n* = 30)	47.8 (*n* = 38)	47.8 (*n* = 68)
Brevoortia sp. (menhaden)	(none caught)	90 (*n* = 1)	90 (*n* = 1)
Urophycis regia (spotted hake)	116.7 (*n* = 7)	97 (*n* = 1)	114.3 (*n* = 8)
Syngnathus louisianae (chain pipefish)	116.6 (*n* = 5)	124.0 (*n* = 2)	118.7 (*n* = 7)
Prionotus scitulus (leopard searobin)	65.0 (*n* = 2)	67.0 (*n* = 3)	66.2 (*n* = 5)
Centropristis striata (black sea bass)	(none caught)	118 (*n* = 1)	118 (*n* = 1)
Larimus fasciatus (banded drum)	110 (*n* = 1)	113.8 (*n* = 14)	113.5 (*n* = 15)
Leiostomus xanthurus (spot)	108.7 (*n* = 23)	104.0 (*n* = 15)	106.8 (*n* = 38)
Micropogonias undulatus (Atlantic croaker)	125.2 (*n* = 30)	127.0 (*n* = 38)	126.2 (*n* = 68)
Stellifer lanceolatus (star drum)	114.5 (*n* = 2)	116 (*n* = 1)	115.0 (*n* = 3)
Peprilus triacanthus (butterfish)	47.5 (*n* = 4)	18.0 (*n* = 2)	37.7 (*n* = 6)
Ancylopsetta quadrocellata (ocellated flounder [Figure 6-7])	(none caught)	95 (*n* = 1)	95 (*n* = 1)
Citharichthys macrops (spotted whiff)	76 (*n* = 1)	(none caught)	76 (*n* = 1)
Etropus crossotus (fringed flounder)	(none caught)	88 (*n* = 1)	88 (*n* = 1)

Notes: Fishes are measured as standard length; shrimp are measured as post-orbital carapace length; the first ≤10 individuals of each species in each trawl sample were measured.

Figure 6-7. Some White Shrimp (*Litopenaeus setiferus*) Were Quite Large, such as this Individual from Trawl Station MI-TR-01

Note: This specimen measured 48 mm in post-orbital carapace length

Figure 6-8. This Juvenile (95-mm SL) Ocellated Flounder (*Ancylopsetta quadrocellata*) was Sampled at Station MI-TR-06 (tow #1)

Note: this was the only ocellated flounder to be collected during the survey (and it was released)

Shannon diversity index values ranged from a low of 0.53 (station MI-TR-07) to a high of 1.10 (station MI-TR-05) (Exhibit 6-27, Figure 6-8). These values are all low due to the relatively low sampling effort (one sample per station in most cases), as many of the taxa that inhabit this area were not sampled during the survey. Given that these index values are for comparison purposes only, rather than to assess the complete epibenthic community parameters of the area, these values suffice. Margalef richness index values ranged from 1.20 to 2.25 and were highest at station MI-TR-05. Station MI-TR-05 also held the highest Shannon diversity index value (1.10). Pielou's evenness values ranged from 0.20 to 0.71 and were highest at station MI-TR-06 due to the even distribution of individuals across the very small number of taxa at this station.

The Margalef richness index is similar to the Shannon diversity index in that it is used to measure variation among a group of taxa. However, unlike the Shannon index, the Margalef richness index does not account for the even distribution of individuals among taxa (evenness).

Exhibit 6-27. Epifaunal Diversity, Evenness and Taxonomic Richness Per Trawl Station

Mean Epifaunal Shannon Diversity Values per Trawl Station			
Station ID	**H' Shannon Diversity Index (log e)**	**J' Pielou Evenness Index**	**D Margalef Richness Index**
MI-TR-01	0.82	0.46	1.20
MI-TR-02	0.97	0.42	2.08
MI-TR-03	0.92	0.37	2.21
MI-TR-04	0.45	0.20	1.49
MI-TR-05	1.10	0.50	2.25
MI-TR-06	0.98	0.71	1.21
MI-TR-07	0.53	0.24	1.50

Notes: Index calculations exclude pelagic species. Station MI-TR-06 data derived from two trawl samples. The remaining stations consist of one trawl sample each.

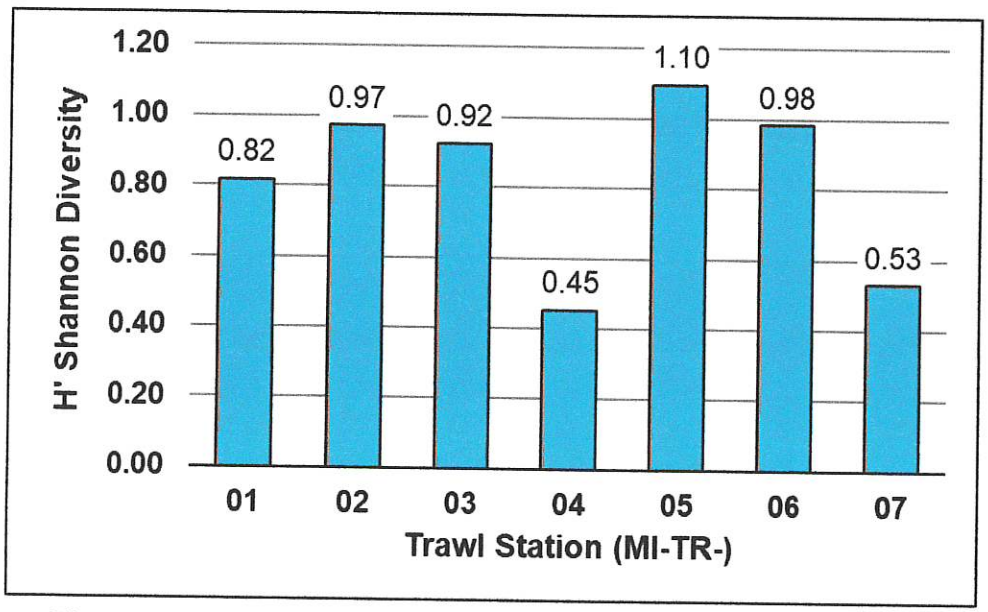


Figure 6-9. Shannon Diversity (H') Index Values Per Trawl Station

When comparing between the nearshore area and outside of this area, the highest Shannon diversity index value was within the nearshore area, with a mean value of 0.97 (Exhibit 6-28, Figure 6-9). The nearshore placement area also had the highest Pielou evenness (0.36) and Margalef richness (2.48) compared to the pooled samples outside of this area. However, the mean values of these indices per station inside the placement area and outside this area are not statistically significant based on the results of two-tailed *t*-tests (*t* statistic < 2.78–3.18, *p*-value = 0.47–0.97) (Exhibits 6-29 through 6-31).

Exhibit 6-28. Epifaunal Diversity, Evenness and Taxonomic Richness Inside and Outside the Nearshore Placement Area

Area	H' Shannon Diversity Index (log e) Value	J' Pielou Evenness Index Value	D Margalef Richness Index Value
Inside Placement Area (pooled results)	0.97	0.36	2.48
Inside Placement Area (mean per station ± SD)	0.90 (± 0.065)	0.42 (± 0.035)	1.83 (± 0.45)
Outside Placement Area (pooled results)	0.59	0.21	2.30
Outside Placement Area (mean per station ± SD)	0.76 (± 0.28)	0.41 (± 0.21)	1.61 (± 0.39)

Notes: Index calculations exclude pelagic species. Each area represents pooled trawl sample results (three trawl samples inside the placement area and five trawl samples for outside this area).

Exhibit 6-29. Statistical Comparison of Epifaunal H' Shannon Diversity Inside and Outside the Nearshore Placement Area

Parameter	Inside Placement Area	Outside Placement Area
***t*-Test Two-Sample Assuming Unequal Variances**		
Mean H' Shannon diversity index value	0.90	0.76
Variance	0.006	0.10
Observations (*n*)	3	4
Degrees of freedom	3	
t statistic	0.82	
t critical two-tail	3.18	
Alpha	0.050	
t-test *p*-value	0.47	
Significantly different?	**No** (*t* statistic < 3.18 and *p*-value > 0.05)	

Exhibit 6-30. Statistical Comparison of J' Pielou Evenness Inside and Outside the Nearshore Placement Area

Parameter	Inside Placement Area	Outside Placement Area
***t*-Test Two-Sample Assuming Unequal Variances**		
Mean J' Pielou evenness index value	0.42	0.41
Variance	0.002	0.057
Observations (*n*)	3	4
Degrees of freedom	3	
t statistic	0.039	
t critical two-tail	3.18	
Alpha	0.050	
t-test *p*-value	0.97	
Significantly different?	**No** (*t* statistic < 3.18 and *p*-value > 0.05)	

Exhibit 6-31. Statistical Comparison of D Margalef Richness Index Inside and Outside the Nearshore Placement Area

Parameter	Inside Placement Area	Outside Placement Area
***t*-Test Two-Sample Assuming Unequal Variances**		
Mean D Margalef richness index value	1.83	1.61
Variance	0.30	0.20
Observations (*n*)	3	4
Degrees of freedom	3	
t statistic	0.56	
t critical two-tail	2.78	
Alpha	0.050	
t-test *p*-value	0.60	
Significantly different?	**No** (*t* statistic < 2.78 and *p*-value > 0.05)	

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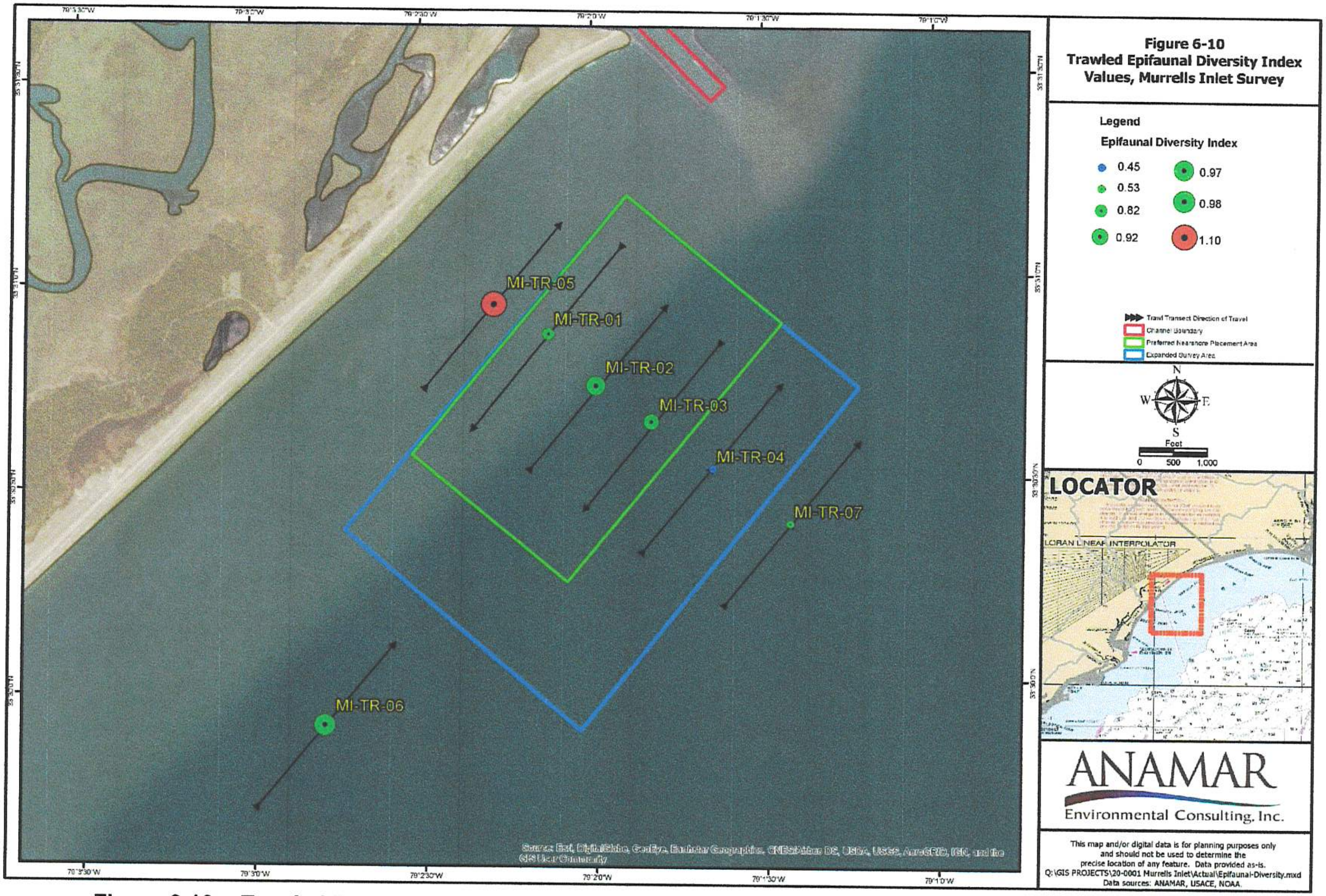

Figure 6-10. Trawled Epifaunal Shannon Diversity Values Mapped Per Station, April 2022 Survey Results

Notes: Pelagic species are excluded. Each station consists of one trawl sample each except for MI-TR-06, which had two samples collected.

6.5.3 Community Structure Based on Trawl Catches

The trawl survey revealed that drums such as the Atlantic croaker and spot *(Leiostomus xanthurus*) are important epibenthic community inhabitants based on trawl densities. Lined sea stars (*Luidia clathrata*), a species known to be significant predators of bivalves, probably prey on some of the bivalve species that were identified in the benthic infaunal catches. This species and other sea stars help churn the uppermost layer of sediment while foraging. Of the arthropods, penaeid shrimp, such as the white shrimp (*Litopenaeus setiferus*), are important scavengers, predators, and prey items. Hermit crabs (*Paguristes* sp.) are scavengers and grazers in the area and probably are important prey items for larger animals. Portunid crabs such as the iridescent swimming crab (*Portunus gibbesii*), act as predator and prey in the softbottom community. Spotted hake (*Urophycis regia*), leopard searobin (*Prionotus scitulus*), and flounders such as the ocellated flounder (*Ancylopsetta quadrocellata*) are also important to the epibenthic community.

Atlantic croaker distribution appears to be tied to temperature (Darovec 1983) more so than to salinity (except during spawning; Darovec 1983), and therefore the presence of this species does not necessarily signify estuarine conditions. Atlantic croaker of the size caught during the trawl surveys feed primarily on polychaete worms, crustaceans, and mollusks (Springer and Woodburn 1960). These fish probably use the survey area for feeding, at least during April.

Spot were the second most abundant drum captured during the survey. Spot feed primarily on amphipods and ostracods as well as small mollusks and annelid worms (Hildebrand and Cable 1930) and are likely feeding on the abundant infauna within the area. Spot are considered euryhaline (Darovec 1983, Able and Fahay 1998) and large numbers are found offshore (up to 15 nautical miles) of Beaufort Harbor, North Carolina (Hildebrand and Cable 1930). Even juvenile spot have been documented in salinities as high as 35.2 ppt (Cowan and Birdsong 1985 in Able and Fahay 1998). Thus, the presence of spot in the trawl samples is not necessarily evidence of estuarine influence. The average size for spot captured during the trawl survey was 106.8 mm SL and are below the length at maturity as determined by Hildebrand and Cable (1930) and Darovec (1983).

Larger species of fishes, such as requiem sharks (Carcharhinidae), red drum (*Sciaenops ocellatus*), black drum (*Pogonias cromis*), bluefish (*Pomatomus saltatrix*), and crevalle jack (*Caranx hippos*) were not sampled due to the limitations of the small trawl gear. Such larger species should nonetheless be expected to frequent the nearshore placement area and the surrounding area at least seasonally. Many of these species may be expected to use the survey area for foraging. Their prey species likely include many of the fishes captured in trawl samples.

Although no batoids were captured in trawl samples, they are expected to use the nearshore placement area and surrounding area at least seasonally. Whiptail stingrays (Dasyatidae), the lesser electric ray (*Narcine bancroftii*), and the clearnose skate (*Rostroraja eglanteria*) feed on polychaete worms and other benthic infaunal organisms such as those identified in grab samples collected during this survey. Spiny and smooth butterfly rays (*Gymnura altavela* and *G. lessae*) prey on forage fishes, crustaceans, and mollusks including those sampled during this survey.

6.6 Non-Native Species

The occurrence of non-native species is of interest to this study as they may proliferate if a site is altered with the addition of dredged material (Science Applications International Corporation 1986, Pequegnat et al. 1990). To address this issue as it relates to this report, an effort was made to identify any non-native species captured during the site designation surveys. To this end, benthic infauna and trawled epifauna were researched for possible non-native species using the

U.S. Geological Survey online database of aquatic nonindigenous species and the following resources:

- U.S. Geological Survey nonindigenous aquatic species online database (https://nas.er.usgs.gov/)
- Invasive Species Specialist Group global invasive species online database (http://www.iucngisd.org/gisd/)
- Jacoby, C., L. Walters, S. Baker, and K. Blyler. 2005. *A Primer on Invasive Species in Coastal and Marine Waters*. Florida Sea Grant College Program Publication SGEB 60, Gainesville, FL. (Available online at: http://edis.ifas.ufl.edu/pdffiles/SG/SG07500.pdf)
- Schofield, P.J., J.A. Morris, and L. Akins. 2009. *Field Guide to Nonindigenous Marine Fishes of Florida*. NOAA National Ocean Service, National Centers for Coastal Ocean Science Technical Memorandum NOS NCCOS 92.

Although the impacts of ecological invasions have been recognized by scientists since at least the late 1950s (Elton 1958), invasion ecology remains a developing science and thus some terms should be defined here in the interest of specificity. The term *non-native* is used to indicate any species not considered native to the east Carolinian biogeographic region, which spans from Cape Hatteras, North Carolina to Cape Canaveral, Florida (Abbott 1986, Baker et al. 2004). The term *invasive* is used only when a non-native species can be reasonably thought to cause harm to native species (e.g., competition, predation, vector for pathogens, hybridization) or to the economy (e.g., hull fouling, clogging intake pipes). The term *cryptogenic* is used when a species' native range is not fully understood, and thus the native or non-native status cannot be established confidently.

No non-native species were identified from benthic infaunal or trawled epifaunal samples from the April 2022 survey. It is possible that non-native species were captured during the survey but were not identified as such, such as species that are cryptogenic or where identification was not pursued to the species level (especially benthic infaunal taxa) for practical reasons.

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